THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 46 NOVEMBER, 1941 No. 5

THE VALUE OF THE ROENTGEN RAY IN THE DIAGNOSIS AND PROGNOSIS OF SILICOSIS*

By WILLIAM M. DOUGHTY, M.D.
CINCINNATI, OHIO

PNEUMOCONIOSIS is a diseased state of the lungs brought on by the inhalation of dust in various occupations.[1] The term pneumonoconiosis was devised by Zenker[2] who described in detail the anatomical picture of the dusty lung. Gardner[3] states, "To the pathologists who coined it, the term pneumoconiosis was useful to describe all pulmonary reactions due to the inhalation of dust," and "If it is to be retained, pneumoconiosis should be defined as a 'condition' of the lungs resulting from the inhalation of dust that may or may not be of clinical significance."

Silicosis is probably the most important clinical and pathological form of pneumoconiosis, and the best definition of this is the one given by the Committee on Pneumoconiosis of the American Public Health Association:[4] "A disease due to breathing air containing silica (SiO_2), characterized anatomically by generalized fibrotic changes and the development of miliary nodulation in both lungs, and clinically by shortness of breath, decreased chest expansion, lessened capacity for work, absence of fever, increased susceptibility to tuberculosis (some or all of which symptoms may be present), and by characteristic X-ray findings." To my knowledge this is the only definition of a disease which specifically designates a roentgenological examination as one of the essential or cardinal points required in the diagnosis. Carlo Leopoldo Visconti in 1871 is credited with being the first to use the term silicosis to denote the pathological condition of the lungs as the result of the inhalation of silica.

What are these "characteristic X-ray findings," and how are they best shown?

First, let us say that roentgenologic studies of the lungs afford a most accurate means of diagnosis and of following changes as they occur in the lungs of these patients. Secondly, I think one is safe in saying that it is impossible positively to diagnose silicosis without a roentgen examination of the lungs. Thirdly, one should not diagnose silicosis positively from the roentgenogram alone, with possibly the one exception of the typical film showing the characteristic discrete nodulation throughout both lung fields associated with a bilateral coalescent area of moderate dimensions in the central portion of the upper half of the lung fields.

Burge[6] expressed this very well when on quoting the committee appointed by the American Public Health Association for the

* Presidential Address delivered at the opening of the Forty-second Annual Meeting of the American Roentgen Ray Society, Cincinnati, Ohio, Sept. 23-26, 1941.

purpose of studying the roentgenological appearance in silicosis he stated, "Only the physician who has examined the subject, has obtained an occupational history of any adequate exposure to silica dust, and has before him a suitable roentgenogram of the chest, should make the diagnosis of silicosis. The roentgenologist not in possession of these facts can merely state whether the shadows which he sees in the film are consistent with his diagnosis."

Let us consider the second of the above questions, "How are these characteristic findings best shown?" Assuming the possession of the proper physical equipment and technical knowledge, we feel that when possible stereoscopic films should be the choice. It might be necessary to make two or three pairs with different degrees of penetration or to use the Potter-Bucky diaphragm to make clear the varying areas of density of tissue. At times, lateral and oblique projections must be added. A roentgenoscopic examination will disclose the amount of elasticity of the lungs, the movement of the diaphragm, and be of help in the selection of the amount of penetration necessary to make the correct exposure for the films.

At the Conference on Silicosis, held at Saranac Lake, New York, in June, 1939, the members in attendance concluded that nodulation must be shown in the lung fields on the roentgenogram before one should diagnose silicosis. This would rule out the earlier first stage classification of silicosis based upon the always questionable finding of increased lung markings and increased density in the hila. This so-called "fibrotic stage" might be of value where serial films are made of employees in the dust hazard industries, but should not be used as a first stage classification of silicosis.

Without attempting any pathological discussion, I will mention some of the more or less characteristic terms used in describing the films of silicotic patients.

Increased density of the hilum and trunk shadows and prominence of the linear markings are findings in many conditions other than pneumoconiosis and are familiar to every roentgenologist.

Discrete nodulation is the one essential finding that must be shown to establish the diagnosis of silicosis. These nodules are small, rounded densities, which vary from 2 to 6 mm. in diameter; they have sharply defined edges and are uniformly distributed throughout both lungs; they are first seen near the hilum, usually on the right side, but once they start forming they spread until they are uniformly and discretely placed throughout both lung fields, though less prominent in the bases and at the periphery. Pendergrass[7] explains this very clearly when he states, "Adequacy of lymphatic flow and degree of respiratory mobility go hand in hand. Perhaps this might account for the frequency of upper lobe tuberculosis and for the mid-lung field changes of silicosis. Perhaps it might also account for the clear peripheral and paracardial zones in the lung fields in patients with pronounced changes due to silicosis with quiescent infection."

Coalescent nodulation occurs when the nodules become more numerous in a fairly small area and the fibrous tissue between them becomes more evident. This causes in that area a definite haziness on the film, which varies in size from 1 to 3 inches vertically, and from ½ to 2 inches in depth. These areas are most commonly seen in the central portion of the upper lung fields, and are almost always bilateral and symmetrically placed.

Conglomerate masses are usually due to the merging of a number of these coalescent areas with the addition of fibrous tissue, into a dense area of larger size. They too are usually in the central and upper part of the lung fields, though they sometimes occupy the greater part of the upper two-thirds of one or both sides. Usually regular in outline, they may at times appear quite irregular.

Emphysema is quite commonly seen in the older and more advanced cases. It begins usually in the costophrenic angles and progresses along the diaphragm until it may

occupy the lower one-fourth or one-third of the thoracic cage. It is almost always bilateral and symmetrical, though in the extreme cases there may be more lobules on one side than on the other. Smaller amounts of emphysema are at times seen in the lung fields surrounding coalescent or conglomerate areas in the upper and mid sections.

Fibrous bands are common in the advanced cases. They extend from the dense fibrous conglomerate mass in the upper lung area, and pass through the emphysematous region, causing tenting or peaking of the diaphragm where they are adherent.

The acute or rapidly developing type of silicosis, fortunately rare, does occur. While this is more commonly seen in the workers in the alkaline abrasive soap manufacturing industries, it also occurs in the crushing of quartz ores as reported by McNally,[8] and has been described by Cole and Cole,[9] Ritterhoff,[10] Gardner, and others. The roentgen examination is of little help in the diagnosis of this type, as the disease may occur and be disabling within two or three years after the initial employment in the dust hazard, too early for the customary nodulation to form and be shown. It is more frequently seen in the young adult employed in an alkaline or almost pure, fine silica dust atmosphere. The films are hazy or look fogged, with only a moderate increased density in the hilum. On postmortem examination, however, the lungs disclose gross numbers of microscopic discrete nodules, and have lost much of their elasticity, with definite increase of the fibrous tissue. These postmortem findings explain the marked haziness shown on the roentgenogram.

Cardiac complications are rarely encountered. Cor pulmonale is about the only recognized heart complication due to silicosis. This is naturally seen only when the elasticity of the lung tissue is almost nil, or in the advanced cases of fibrosis and conglomerate masses with its associated high grade of emphysema.

Complications shown in the roentgenogram are confined to the lung. For some unexplainable reason, pulmonary tuberculosis is more common and the mortality from it is greater in the silicotic than the general population. In fact, it is the most common cause of death among silicotic patients. Pulmonary carcinoma may occur coincidentally with silicosis, but in only one section, among the cobalt miners in Germany, has there ever been shown a greater incidence of carcinoma of the lung in silicotics than among the general population.

According to Gardner, Riddle, and Pierpont,[11] "The incidence of pneumonia or broncho-pneumonia is no more common, nor is the death rate any greater among the silicotic than in the general population."

With the advent of industrial compensation in many states, a large number of the older employees are applying for permanent total disability claims and deservedly so. Many have advanced silicosis, usually complicated by pulmonary tuberculosis either active or, more commonly, of the chronic fibroid type. Others show the massive conglomerate type with the associated emphysema, at times complicated by cor pulmonale. After a number of years spent in contacting these workers, respect for their stamina and integrity is greatly increased; many of these older employees continue to work long past the time when they should stop. Many, however, have only the simple, uncomplicated silicosis which in itself is not disabling. But they themselves are the victims of advancing age and at the end of many years of hard physical labor show the effects of its toll on the human body, all of which are not due to silicosis. These are real problems for the doctor, who, if he should be fortunate enough to have a series of roentgenograms for the individual cases extending over a period of eight or ten years, will find them of great value in the correct analysis of these cases.

The above described characteristic lung changes seen in the various stages of silicosis may occur either as silicosis simplex, with or without associated coalescent areas, or as the massive conglomerate fibrotic

type. With such a roentgenogram, a history of adequate injurious dust exposure and the associated customary physical findings, one usually has little difficulty in arriving at a correct diagnosis.

Unfortunately, however, and especially in the advanced cases, infection is usually present and is most frequently tuberculous in type. This tuberculosis may be either active or of the chronic variety. The tuberculosis may have been present before the silicosis occurred, or may have started secondarily. In either instance the prognosis is bad, and in many cases, even though the patient has had an adequate exposure to silicon dioxide, it is quite difficult to tell whether or not silicosis is actually present, since the nodules are very difficult to find on the roentgenogram.

I shall not attempt to describe all the various pathological changes shown with this combination of silicosis and pulmonary tuberculosis. They are even more varied in their picture than the single infection of pulmonary tuberculosis. In the less massive fibrotic type, when a sufficient exposure to silica has occurred, one can usually see the nodules discretely placed. When associated with the various typical lung changes seen in the tuberculous patient, the diagnosis is again relatively simple. The silicotic nodules are usually more uniformly distributed in both lungs, their size is from 2 to 6 mm. in diameter, and their edges are more sharply defined than the mottling seen in pulmonary tuberculosis. While one usually thinks of cavities as of tuberculous origin, they may occur in the silicotic lung totally free of tuberculous infection. It is usually less difficult in these questionable cases of combined infection to establish the diagnosis of tuberculosis than that of silicosis, but there are a certain number of such cases where the sputum remains constantly negative to the tubercle bacilli, and a large number of postmortem lung sections must be examined before they can be demonstrated.

In the follow-up work among employees of dust industries, serial films made every six months or every year are more valuable than any other examination. They also make an invaluable record for comparison. If on any later film the number of the silicotic nodules has lessened, one can be sure that the diagnosis of silicosis was incorrect, as the nodules never disappear once established, though they may be clouded over by active infection or massive fibrotic tissue.

In the differential diagnosis in the earlier or moderately advanced cases, many conditions must be considered, such as miliary tuberculosis, siderosis, the small metastatic malignant deposits especially from hypernephroma, many of the yeast fungi deposits, Boeck's sarcoid and sprue. In the more advanced cases one must consider pulmonary tuberculosis, cancer, emphysema, bronchiectasis, atelectasis and the lung changes which naturally occur in advancing age (when not only is there more fibrous tissue but the lymphatics themselves are normally more evident), and chronic cardiac disease with the usual accompanying arteriosclerosis and lung changes due to the decompensation.

In conclusion, may I say, that while such physicians as R. R. Sayers and A. J. Lanza, with their large experience in all phases of this silicotic dust hazard, can with a great degree of certainty state that if given the number of years a worker has been employed, and an accurate dust count of the air he has breathed with the size of the particles of silicon dioxide, or, if permitted to see a group of employees going to work walking up a moderate grade, they can quite accurately describe the pathology present in the thorax, I feel that most roentgenologists will have a much better average in the diagnosis of silicosis in the various stages, if we would adhere to the usual rules laid down for us, namely, that before a definite diagnosis of silicosis can be made one must have, besides the necessary roentgenograms of the chest:

1. An accurate history of the patient's employment during his working life.
2. An accurate dust count made at the breathing level of the patient.

3. The percentage of silicon dioxide in the atmosphere he breathes and the size of the particles present in this count.
4. The report of a careful medical history and physical examination.

From a roentgenological point of view the above remarks do not preclude the statement that what was seen on the films suggests the possibility of silicosis. Nevertheless, I think it fair to conclude that it is not possible to make an accurate diagnosis of silicosis without a roentgen examination, nor should one make a positive diagnosis of silicosis based only upon a roentgen examination.

REFERENCES

1. Gardner, L. U. Diagnosis of silicosis, with special reference to roentgenological manifestations. *Ann. Int. Med.*, 1936, *10*, 166–173.
2. Zenker. Pneumonoconiosis. In: Silicosis and Asbestosis. A. J. Lanza, editor. Oxford University Press, 1938, p. 6.
3. Gardner, L. U. Pathology and roentgenographic manifestations of pneumoconiosis. *J. Am. M. Ass.*, 1940, *114*, 535–545.
4. Committee on Pneumoconiosis, American Public Health Association. Year Book, 1932–1933.
5. Collis, E. L. Melroy Lectures, 1915.
6. Burge, F. W. Pneumonoconiosis. Cyclopedia of Medicine, 1938, p. 322.
7. Pendergrass, E. P. Silicosis and Asbestosis, 1938, p. 101.
8. McNally, W. D. Acute silicosis. *J. Indust. Hyg. & Toxicol.*, 1941, *23*, 45–49.
9. Cole, L. G., and Cole, W. G. Roentgenologic diagnosis of pneumoconiosis (silicosis) and use of the "electric eye" to determine regional densities. *Radiology*, 1939, *33*, 261–290.
10. Ritterhoff, R. J. Acute silicosis. *Am. Rev. Tuberc.*, 1941, *43*, 117–131.
11. Gardner, Riddle and Pierpont. Conference on Silicosis, Saranac Lake, N.Y., June, 1939.

LINEAR SHADOWS IN THE LUNG

(INTERLOBAR PLEURITIS, ATELECTASIS AND HEALED INFARCTION*)

By FELIX FLEISCHNER, M.D., AUBREY O. HAMPTON, M.D., *and* BENJAMIN CASTLEMAN, M.D.
BOSTON, MASSACHUSETTS

IN A previous paper a combined roentgenological and pathological method of postmortem examination of the lungs with special application to the study of pulmonary embolism and infarction was presented.[1] In this work it was shown that in their healing and healed stages, infarcts produce linear shadows on the roentgenogram. This present paper deals with a more detailed study of these shadows, and in addition two other conditions which produce similar linear shadows, i.e. plate-shaped foci of atelectasis and interlobar pleuritis, will be considered.

In the usual routine postmortem examination of the lungs, lesions that produce linear shadows on the roentgenogram will almost always be overlooked or if seen will not be removed for microscopic examination for a more exact diagnosis. The pathologist must know that a linear shadow was seen on the roentgenogram of the patient because, unless the lesion is very large and obvious, routine sections of the collapsed lung after removal from the body, even if done carefully, will not reveal the full extent of the process. Unless forewarned, the pathologist might dismiss a localized pleuritis as merely the result of old tuberculosis and not realize that the fibrosis may extend into the parenchyma as a linear scar and be a healed infarct that produced a linear shadow on the roentgenogram. Unless forewarned, the pathologist might not realize that the faint bluish focal atelectatic area seen on the surface of a lower lobe is part of a longer plate-like focus of atelectasis that had produced a linear shadow on the roentgenogram. It is therefore important for the roentgenologist to inform the pathologist to be on the look-out for these lesions when they are present on the roentgenogram. The incidence of these lesions will definitely be increased if routine postmortem teleroentgenograms are taken prior to the autopsy,† because many patients may not have had antemortem roentgenograms and very often a plate-like focus of atelectais is agonal. It was only by this cooperative method of study that we have been able to understand the nature of these processes.

INTERLOBULAR PLEURITIS

The roentgenological appearance of interlobar pleurisy is well known and therefore a brief survey will suffice. The normal interlobar pleura is easily demonstrated on a roentgenogram as a thin linear shadow. The posteroanterior views show the septum between the upper and middle lobes, and the lateral and oblique views demonstrate the fissure between the upper and lower lobes. Anomalous fissures, such as are produced by the azygos lobe in the right upper lung field and the cardiac lobe, are also seen in the posteroanterior views, even though they are normal. Fibrinous or small amounts of serous exudate in the interlobar space, as well as scarring or thickening of the pleura, results in an increase in the width of these linear shadows. Larger amounts of interlobar exudate are visualized as band or spindle-shaped shadows when they are projected on edge. The diagnosis of these interlobar effusions presents no difficulties if both adjacent lobes are normal and well aerated. Lesions about the right middle lobe, however, have often been the source of erroneous diagnoses. Recent studies of the appearance of collapse of the middle lobe

† The technique of taking postmortem teleroentgenograms was described in a previous paper.[1]

* From the Departments of Roentgenology and Pathology, Massachusetts General Hospital, Boston. Read at the Fortieth Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 19–22, 1939.

have resulted in a better understanding of these conditions and they have enabled us to distinguish a collapsed middle lobe from interlobar effusion.[2] A differential diagnosis between collapse of the middle lobe and an encapsulated interlobar effusion between the middle and lower lobes or middle and upper lobes is sometimes difficult. It must be remembered that when the middle lobe collapses to form a band-shaped or slightly elliptical shadow it does not occupy the anatomical location of an interlobar fissure. The shadow seen in the lateral view ends sharply at the lung root and there is compensatory emphysema above and below the collapsed lobe. This is in contrast to the location and gradual fading of the shadow together with the increase in density of the surrounding lung, seen associated with interlobar disease.

PLATE-LIKE ATELECTASIS

Plate-like or band-shaped roentgenological shadows (Figs. 1*A* and 2*A*) have been observed for many years but it was only through the recent studies of one of us (Fleischner)[3,4,5] that their atelectatic nature and pathological significance were revealed.

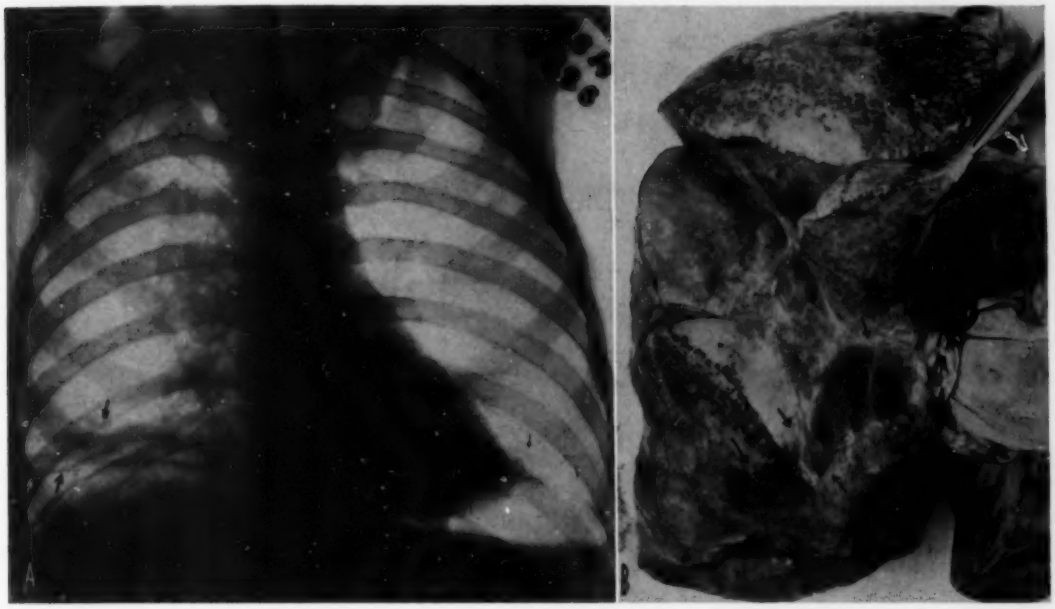

Fig. 1*A*. Postmortem examination. Plate-like foci of atelectasis. Note multiple transverse linear shadows at the right base and single transverse linear shadow at the apex of the heart. There is air beneath the diaphragm.

Fig. 1*B*. Middle and upper lobes are drawn upwards to expose the anterior surface of the right lower lobe. The dark, broad, wave-like band extending across the base of the lower lobe represents the areas of atelectasis seen in Figure 1*A*. On the fresh non-inflated specimen the dark band is represented as a smooth, glistening, bluish-gray discoloration. Note the slight depression at the lateral margin of the lower lobe at the extremity of the band of discoloration. Although there is only one focus of atelectasis, it is projected on the roentgenogram as multiple lines because the atelectasis is not in one plane.

These horizontal dense lines are often seen in the lower lung fields and vary from barely visible thin lines to shadows of about 5 mm. in thickness. They are usually located about 1 to 3 cm. above the dome of the diaphragm, but may be so low that they are seen only in the lateral view or through the gas bubble in the stomach. Only rarely are they seen in the upper lobes. They may be unilateral or bilateral, single or multiple, and although usually horizontal may occasionally be oblique. When seen in the extreme costophrenic angles as short lines, they may

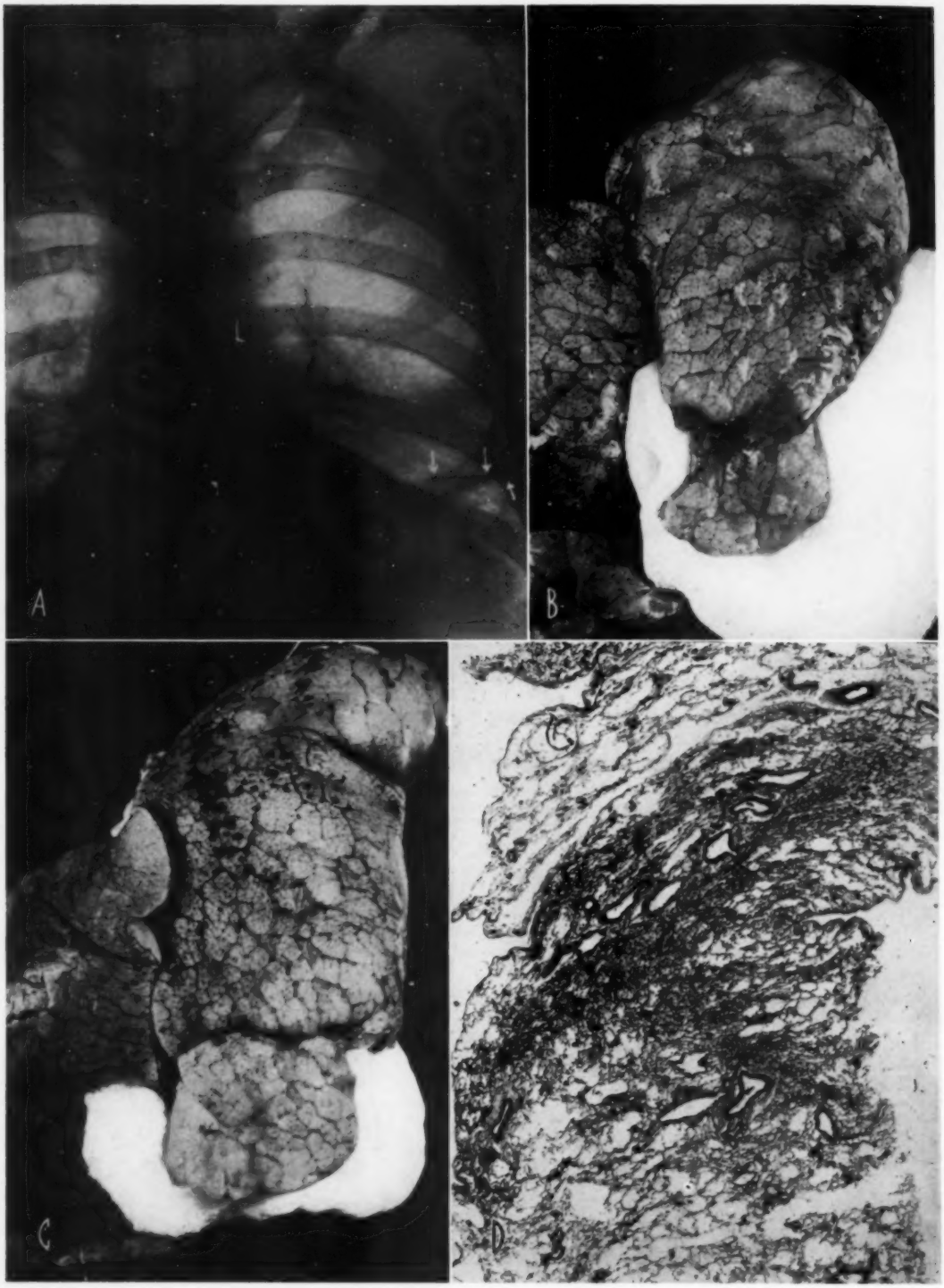

FIG. 2*A*. Postmortem examination. The dense horizontal linear shadows at the left base are due to atelectasis.

FIG. 2*B*. The transverse defect in the inferior margin of the left upper lobe represents the shadow seen in Figure 2*A*. The lungs have not been inflated.

FIG. 2*C*. The left lung has been inflated by careful introduction of compressed air. Transverse defect seen in is now a deep wave-like fissure produced by atelectasis and this is its true appearance during life.

FIG. 2*D*. Low power photomicrograph of an elastic tissue preparation through the atelectatic focus. Note sharp zone of atelectatic alveoli and the focal emphysema superiorly and inferiorly.

be interpreted as pleural adhesions or small amounts of fluid. Band-shaped foci of atelectasis always extend to a pleural surface. They may extend to the medial or the lateral chest wall, but they do not cross interlobar fissures. The two-dimensional character of the lesion is demonstrated by the disappearance of the shadow when the patient is bent forward or backward or by its persistence when the patient is rotated. Since the transverse segments of collapsed lung tissue are not in the same plane, the shadow is often composed of multiple lines and these can be varied by shifting the position of the patient or the tube. During respiration these lines move upward and downward independent of the lateral chest wall, thus showing the absence of pleural adhesions. It is obvious that roentgenoscopy is of considerable value in the diagnosis. In the case of pure atelectasis the shadows are normally well defined but may become fuzzy if additional pneumonitis is present. When the surrounding lung is clear of disease, localized emphysema is apparent above and below the lesion.

The gross pathological appearance of these foci of atelectasis is characteristic. It is helpful to examine the lung in situ, preferably with the trachea tied before the pleural cavities are opened, so that the plate-like atelectasis will be conspicuous and its exact location determined. Even after the lungs are removed and with the trachea open, the atelectatic area will be easily seen. It presents itself on the pleura as a grayish-blue, depressed, horizontal, linear band of non-aerated or only slightly aerated lung (Figs. 1*B* and 2*B*). It is about 0.5 to 2 cm. in width in the deflated specimen (lung after removal from the body) and usually traverses the whole width of that surface of the lobe involved. When the lung is inflated (injection of formalin by gravity through the trachea), the focus of atelectasis usually does not re-expand so that the expansion of the alveoli above and below it produces a cleft in the atelectatic area (Fig. 2*C*). Two factors are responsible for this phenomenon. The surface tension of the collapsed alveoli is probably too great to allow separation of the alveolar walls, and secondly the regional bronchus may be filled with a mucous secretion preventing inflow of fluid. In some cases where the atelectasis is not complete, reinflation of the specimen may partially re-expand the atelectatic area.

Microscopic examination demonstrates completely or partially atelectatic flattened alveoli, without any destruction of alveolar walls (Fig. 2*D*). The atelectatic alveoli are arranged so that their walls are parallel to the horizontal cross section of the body. This is evidence that the flattening process has been in the cranio-caudad direction, a fact which will be further developed in the discussion of the pathogenesis of this condition. The parenchyma above and below the lesion usually shows focal compensatory emphysema to allow for spatial readjustment within the lung. The emphysematous alveoli show some flattening, the long axis of the alveoli being in the same cranio-caudad direction.

The pathogenesis and mechanism of plate-like atelectasis have been previously discussed by one of us (Fleischner)[3,4,5] but the added pathological verification of the cases reported here warrants further explanation and even repetition. This condition is always secondary to other pathological processes that interfere with respiration. Often it is an inflammatory process in the abdomen, especially in the subphrenic regions, which interferes with the diaphragmatic action and produces decreased respiration on the side involved. Occasionally the appearance of a plate-like focus of atelectasis is the first evidence of disease below the diaphragm and may give the clue as to which side is involved and where to operate. The pain during respiration in cases of chest wall trauma, pleurisy or a pulmonary infarct may decrease respiration and embarrass the ventilation on the affected side, cause retention of the bronchial secretions, produce bronchial obstruction, and finally atelectasis. The bronchial obstruction that is produced must of necessity be in the more easily obstructed smaller bronchi. A large

bronchus could not be obstructed so easily. At first the atelectasis is conical in shape and surrounds the involved bronchus but very soon it assumes a horizontal plate-like shape because any degree of collapse can occur only in the cranio-caudal direction. Retraction of the pleural margin is not possible in the horizontal direction because of the fixation of the bronchus to the mediastinum medially and because the lung cannot recoil from the chest wall laterally, posteriorly or anteriorly. The only possible direction remaining for atelectasis to occur is in the cephalo-caudad, and this action is facilitated by the diaphragmatic excursion which is regularly impaired, as has been shown by kymography (Sousa)[6].

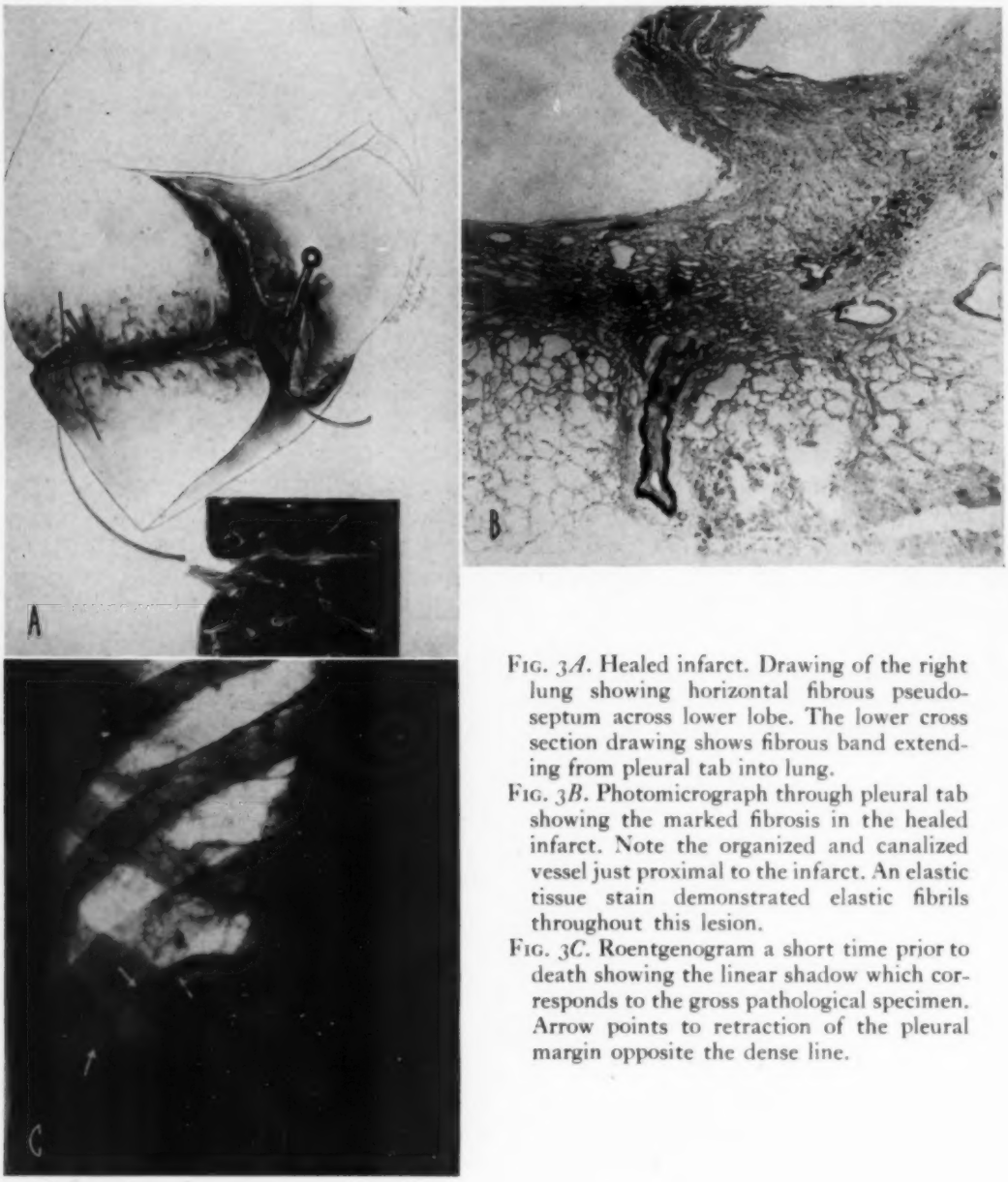

FIG. 3*A*. Healed infarct. Drawing of the right lung showing horizontal fibrous pseudo-septum across lower lobe. The lower cross section drawing shows fibrous band extending from pleural tab into lung.

FIG. 3*B*. Photomicrograph through pleural tab showing the marked fibrosis in the healed infarct. Note the organized and canalized vessel just proximal to the infarct. An elastic tissue stain demonstrated elastic fibrils throughout this lesion.

FIG. 3*C*. Roentgenogram a short time prior to death showing the linear shadow which corresponds to the gross pathological specimen. Arrow points to retraction of the pleural margin opposite the dense line.

This explanation of the pathogenesis is supported by the three pathological findings mentioned above in horizontal plate-like

foci of atelectasis: (1) the elastic fibers in the collapsed zone in horizontal arrangement parallel to the horizontal extension of the atelectatic focus, (2) the presence of compensatory emphysema in the adjacent parenchyma in which the alveoli are elliptical with their long diameters perpendicular to the atelectatic plate, and finally (3) the presence of secretions in the regional bronchus producing obstruction.

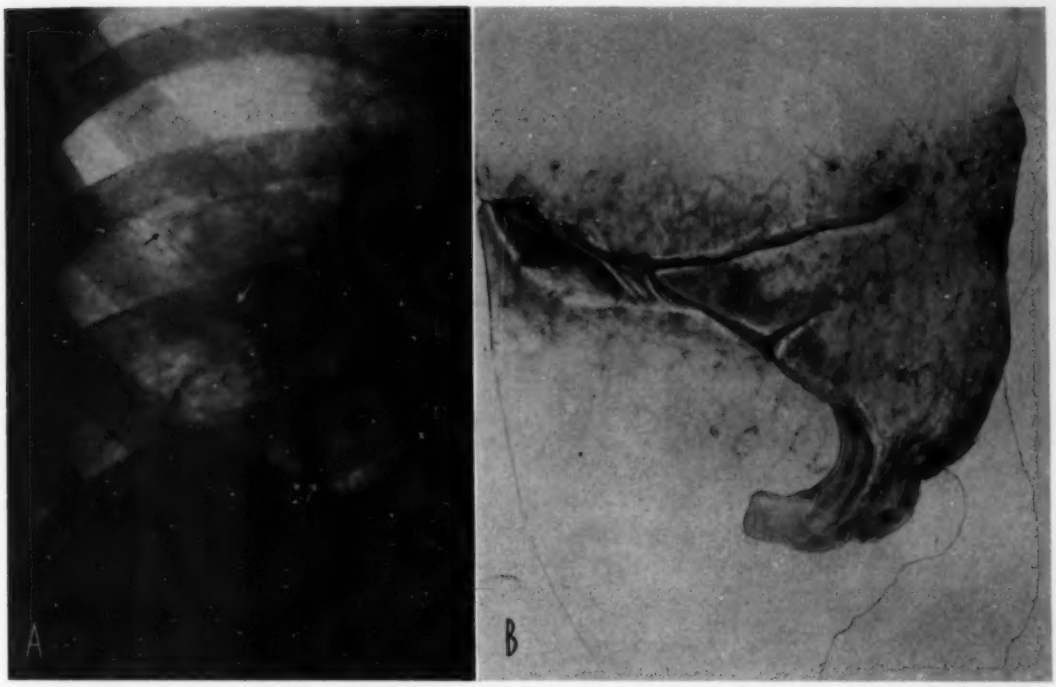

Fig. 4*A*. The sharp, dense, oblique line extending upward and laterally from the diaphragm represents the lateral margin of a healing infarct of the middle lobe. The mottled density medial to this line represents consolidation and incomplete aeration due to the infarct. Interlobar fissure is faintly visible above as a horizontal line. Middle lobe is markedly reduced in size.

Fig. 4*B*. Artist's drawing of the lateral aspect of the middle lobe and fissure between upper and lower lobes of Figure 4*A*. The retraction of the middle lobe is apparent, leaving a sulcus where there is a pleural tab. The dark inferolateral margin of the middle lobe represents the healing infarct.

HEALED PULMONARY INFARCTS

In the previous paper[1] it was shown that bland pulmonary infarcts are always in contact with one or more pleural surfaces, that their longest axis is parallel to the pleura, and that the shape of the infarct corresponds to the shape of the lung involved. It was further pointed out that the cardiac or mesial margin of the area of consolidation was sharp in outline and convex or "hump-shaped." A correlation of the roentgen shadows with the gross and pathological findings was presented and it was demonstrated that an infarct undergoes a definite cycle, beginning as an acute hemorrhagic lesion, passing through a healing stage and finally ending in a scar. The roentgenological appearance of this cycle is well illustrated in a recent paper by K. S. Smith.[7] In the acute stage an infarct is only fairly sharp in outline but later as it reduces in size it becomes sharper and smaller. It is at the healing and healed states that the infarct may produce a sharp dense line and be mistaken for plate-like atelectasis or interlobar pleuritis. These linear shadows produced by infarcts are not confusing if

FIG. 5. Multiple linear shadows at the left base in a patient with typical history of multiple pulmonary infarcts. Examination three weeks after last attack. Note the nodular shadow at the axillary line at the extremity of two of the dense lines. This nodular shadow can often be demonstrated in the healing stage of an infarct.

follow-up examinations have been done during the time of their formation. The characteristic picture (Figs. 3 to 7) is that of a dense single line running in almost any direction but always reaching the pleural surface, where it often ends at a nodular rounded shadow. This nodular mound-like shadow (Fig. 5) lies flat against the pleural surface and its center is convex towards the linear shadow. There may be a V-shaped thickening of the pleura or retraction of the pleural surface instead of the mound-like shadow. The majority of healed infarcts occur in the lower lobes and the linear shadows may be parallel to interlobar fissures or perpendicular to any pleural surface.

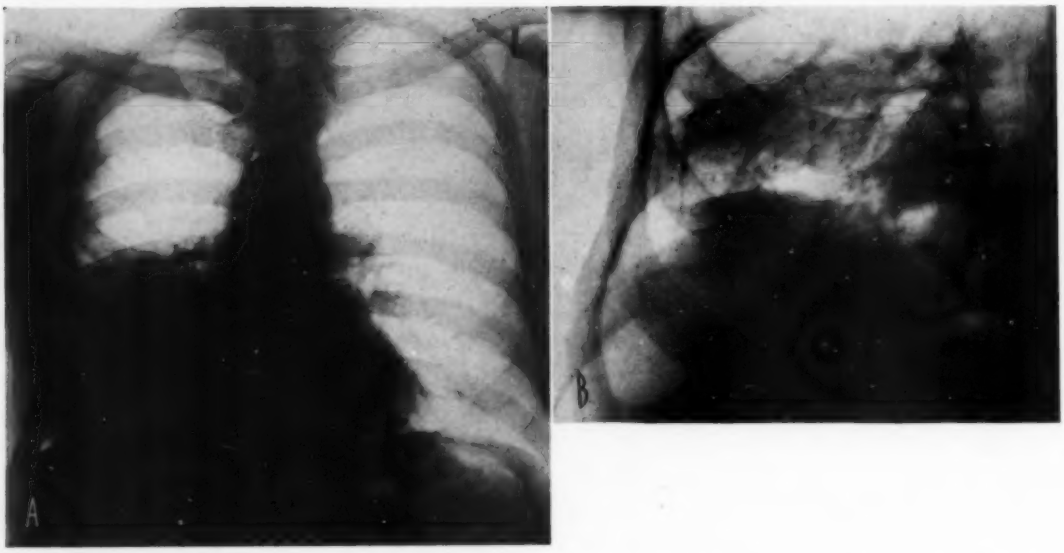

FIG. 6*A*. Multiple infarcts in an ambulatory patient with phlebitis of sixteen years' duration. Chief complaint—dyspnea on exertion. No pain or hemoptysis. Picture simulates cancer. There is a healed infarct in the lung at the apex of the heart.

FIG. 6*B*. The right base of the same patient as Figure 6*A* six months later. He has had ligation of the deep veins of the leg and intra-abdominal ligation of the deep pelvic veins. Following the first operation he had definite clinical signs of pulmonary infarcts for the first time. This was followed by pleural effusion. At present he has no respiratory symptoms. Note numerous dense lines running in all directions at the site of the previous areas of consolidation. There are probably two areas of consolidation remaining, but all the other infarcts are represented only by sharp dense lines.

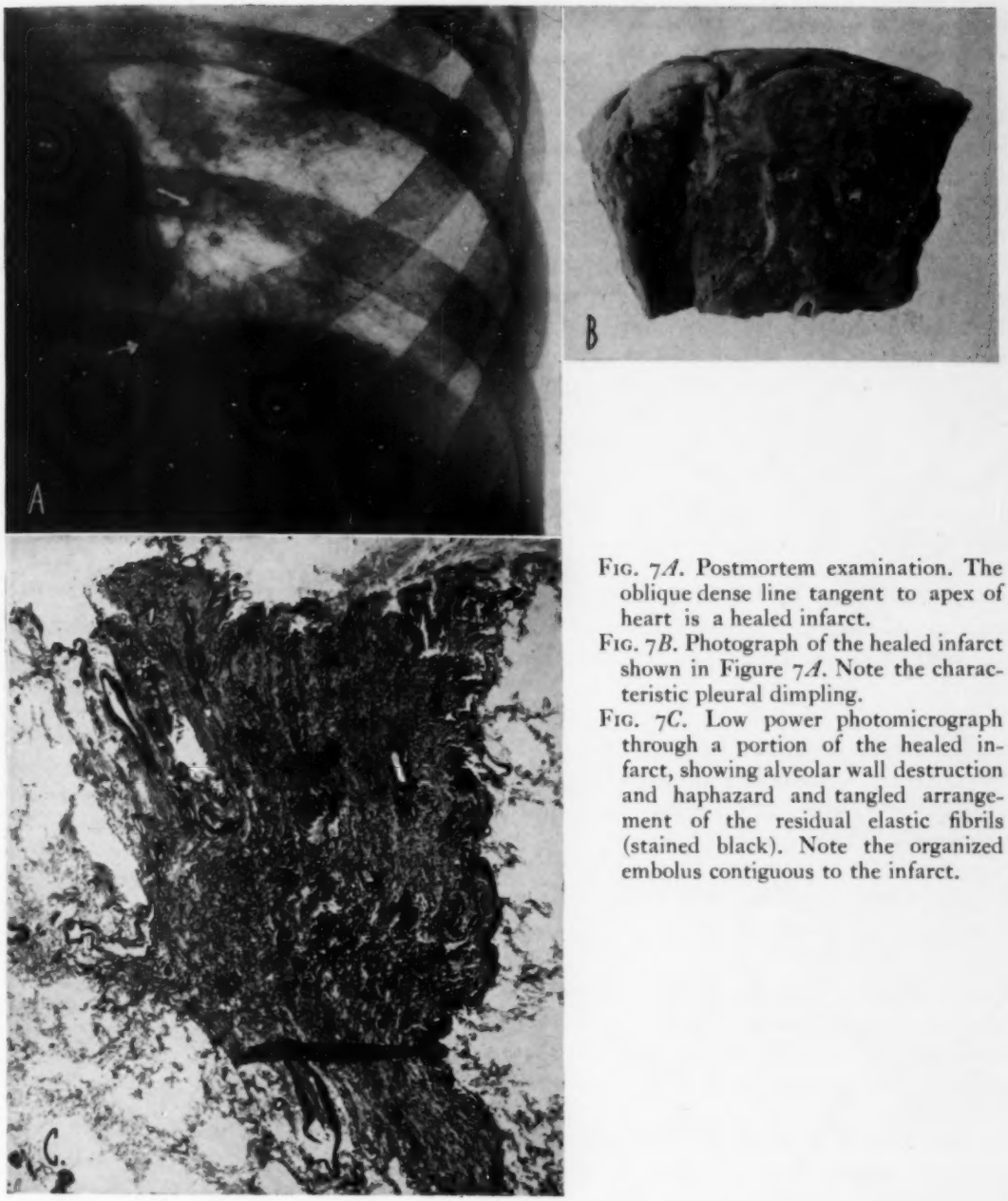

Fig. 7*A*. Postmortem examination. The oblique dense line tangent to apex of heart is a healed infarct.

Fig. 7*B*. Photograph of the healed infarct shown in Figure 7*A*. Note the characteristic pleural dimpling.

Fig. 7*C*. Low power photomicrograph through a portion of the healed infarct, showing alveolar wall destruction and haphazard and tangled arrangement of the residual elastic fibrils (stained black). Note the organized embolus contiguous to the infarct.

The lung is usually reduced in size due to the scarring, especially if multiple large infarcts have been present. These shadows are usually in one plane and therefore each projects only as one line. They may vary from 1 to 10 cm. in length and may be single or multiple. A more complete study of the microscopic pathology of healed infarcts has been recently published by one of us (B. C.).[8]

DIFFERENTIAL DIAGNOSIS

The differential diagnosis of linear and band-shaped shadows in the lungs must include interlobar pleurisy, atelectasis, healed infarcts and the scarring of old destructive

infections. The clinical histories in cases of interlobar pleurisy, infarct, atelectasis and scarring in the lungs are often similar enough to make it impossible to use clinical data alone in differential diagnosis. Furthermore, there is an intimate histologic and pathologic relationship. For example, an infarct may produce pleurisy, atelectasis and scarring; pleurisy may produce atelectasis and interlobar scarring; persistent atelectasis may become infected secondarily and these subsequent inflammatory changes may produce pleurisy or fibrosis. It must be remembered that interlobar pleuritis and plate-like atelectasis are much more common than healed infarcts.

Interlobar pleurisy can usually be readily differentiated from healed infarcts or plate-shaped atelectasis if the anatomical location of the linear shadow corresponds to the position of the interlobar fissure. It may present as a long line of equal thickness corresponding to the length of the fissure but it is usually associated with other evidence of pleurisy such as fluid or pleural thickening near it. Although infarcts frequently are adjacent to the interlobar pleura, they are seen as a more nodular unilaterally placed shadow near the thin line of the readily recognized interlobar fissure. Plate-like atelectasis does not occur in the location of interlobar fissures. If the linear shadow is perpendicular to one of the interlobar fissures, interlobar pleurisy is readily ruled out and the differential diagnosis lies between healed infarct and plate-shaped atelectasis.

Healed infarcts and plate-like atelectasis, although often difficult to differentiate, may show the following features: the shadows of infarcts (Figs. 3 to 7) are usually shorter than atelectasis; are in a single plane, each infarct producing one line; may end in nodular extremities and may run in any direction. The plate-like foci of atelectasis (Figs. 1*A* and 2) are usually long; traverse the entire portion of the lung involved, extending from one pleural surface to another; are often multiple; occur in different planes, one focus producing multiple closely placed, nearly parallel lines; and show no nodular irregularities. In atelectasis the pleura may show a V-shaped retraction but there is usually no regional thickening. Other important differences between these two lesions are: (1) the linear shadow of plate-like atelectasis usually disappears within a few days, whereas that of a healed infarct persists; (2) the diaphragmatic excursion is nearly always limited in plate-like atelectasis, but this feature is rare in a healed infarct; (3) although both atelectasis and infarction occur predominantly in the lower portions of the lungs, infarcts unlike atelectasis are not uncommon in the upper lung fields.

SUMMARY

A detailed study, including differential diagnosis and pathological confirmation of the linear roentgen shadows caused by interlobar pleuritis, plate-like atelectasis and healed infarction, is presented.

REFERENCES

1. Hampton, A. O., and Castleman, B. Correlation of postmortem chest teleroentgenograms with autopsy findings, with special reference to pulmonary embolism and infarction. Am. J. Roentgenol. & Rad. Therapy, 1940, *43*, 305–326.
2. Hampton, A. O., and King, D. S. The middle lobe of the right lung; its roentgen appearance in health and disease. Am. J. Roentgenol. & Rad. Therapy, 1936, *35*, 721–739.
3. Fleischner, F. Atelektase und gerichteter Kollaps der Lunge. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1936, *53*, 607–625.
4. Fleischner, F. Plattenförmige Atelektasen in der Unterlappen der Lunge. *Fortschr. a. d. Geb. d. Röntgenstrahlenn*, 1936, *54*, 315–321.
5. Fleischner, F. Ueber das Wesen der basalen horizontalen Schattenstreifen im Lungenfeld. *Wien. Arch. f. inn. Med.*, 1936, *28*, 461–480.
6. Sousa, A. Atelectasias em disco. *Imprensa méd., Lisbon*, 1936, *4*.
7. Smith, K. S. Radiology of pulmonary infarction. *Quart. J. Med.*, 1938, *7*, 85–93.
8. Castleman, B. Healed pulmonary infarcts. *Arch. Path.*, 1940, *30*, 130–142.

Vol. 46, No. 5

FUNNEL CHEST DEFORMITY AND ITS RECOGNITION IN POSTEROANTERIOR ROENTGENOGRAMS OF THE THORAX*

By LESTER W. PAUL, M.D., *and* M. R. RICHTER, M.D.†
MADISON, WISCONSIN

THE deformity of the sternum and thorax known variously as funnel chest, Trichterbrust, pectus excavatum, koilosternia, chone-chondrosternon, etc., has been studied extensively from the clinical and surgical aspects, and a number of recent publications have described this condition so thoroughly that these phases of the subject will only be treated briefly in this communication.[1,2,3,5] The review by Ochsner and DeBakey[5] is recommended particularly to those who may be interested in a comprehensive survey. The deformity is recognized readily on clinical examination and in lateral roentgenograms of the thorax. The changes produced in the posteroanterior roentgenogram are apparently not so well known.

Our purpose is to describe the typical frontal silhouette of the chest produced by funnel chest deformity and we believe it can be recognized in the majority of instances in the frontal projection alone. Briefly, this deformity consists in an oval or funnel shaped depression of the body of the sternum and its adjacent costal cartilages. The depression involves the body below its junction with the manubrium. As a result an angulation is formed between the costal cartilages and ribs, and the sternum usually rotates somewhat on its long axis so that the anterior surface faces toward the right side, although the opposite may be true. The depth of the depression varies considerably with a corresponding variation in the vertebrosternal diameter which may be narrowed to only a few centimeters. This results in considerable distortion and displacement of the mediastinal structures. The heart is usually displaced to the left and rotated on its longitudinal axis. Absence of such cardiac displacement has been ascribed to the presence of mediastinal adhesions. The mediastinal pleural space becomes increased in width as a result of the depressed anterior thoracic wall, causing a transverse compression of the lungs on both sides. Because of the more caudal position of the diaphragm the vertical diameter of the lungs is increased. The esophagus may be compressed.

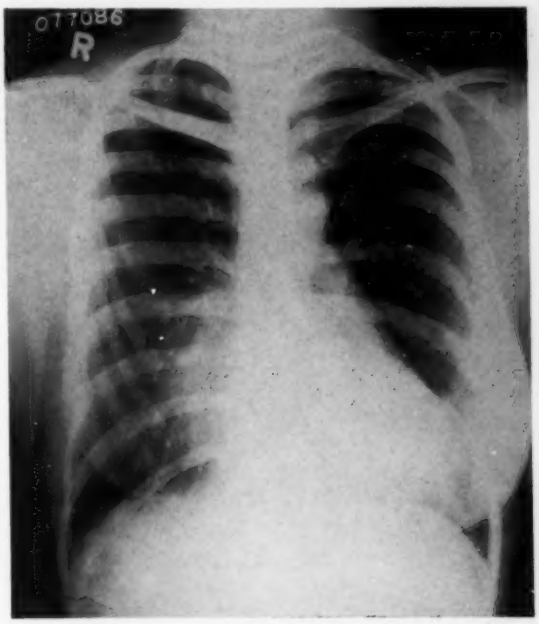

FIG. 1. Typical frontal silhouette of the chest in the presence of well defined depression of the sternum. Sharp downward slanting of the ribs, displacement of the heart to the left with indistinctness of the right border and diffuse cloudiness of the medial lower right lung field are demonstrated.

The clinical manifestations of funnel chest have been of particular interest to clinicians and surgeons. It is generally agreed that in the majority of cases there have been few or no symptoms. These,

* From the Department of Radiology and Physical Therapy, University of Wisconsin Medical School and the State of Wisconsin General Hospital.
† Now residing in Milwaukee, Wis.

when present, are usually referable to the cardiovascular system and consist in precordial pain, palpitation and dyspnea. Cases of this type have been reported and attempts at correction of the deformity have been described by a number of surgeons. Most cases of funnel chest deformity are congenital in origin and frequently inherited. Among the causes listed in the acquired group are rickets and trauma.

The roentgenologist's interest in this condition lies in its detection on roentgen examination of the chest and a recognition of the distortion and displacement phenomena which may be produced. The diagnosis is readily made on physical examination and in lateral roentgenograms of the chest. However, even though the depression of the sternum cannot be seen in the frontal projection, the changes in the rest of the bony thorax and in the lungs and mediastinal structures make it possible to recognize it even when roentgen examination is confined to the posteroanterior view. Although good roentgen practice may call for roentgenoscopic examination and lateral views in the routine study of the chest, this is not always possible, especially in mass surveys. Of greater importance than recognition of the deformity is the fact that the displacement and compression changes may be misinterpreted as evidence of mediastinal or pulmonary disease unless one is familiar with the clinical aspects of the case.

Seven cases of this deformity have been studied roentgenologically and the following features as seen in the frontal projection of the chest are considered of value in its recognition:

(1) Sharp downward slanting of the anterior arcs of the ribs. In addition to the slant, the ribs, anteriorly, are usually straight. The degree of slant varies with the severity of the depression.

(2) Displacement of the cardiac shadow to the left with a tendency toward mitralization of its contour. This has been described previously.[1,3,4,6]

(3) Indistinct right heart border which becomes lost in the shadow of the spine. Even when not displaced, the right border

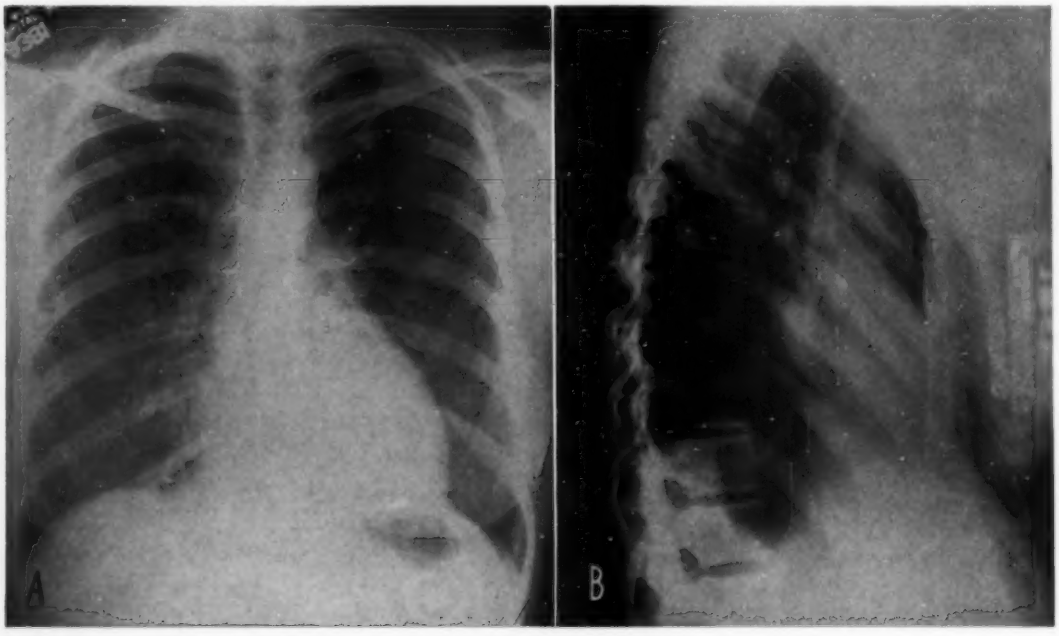

FIG. 2. Moderate funnel chest deformity. *A*, posteroanterior view shows downward slanting of the anterior segments of the ribs, displacement of the heart to the left and cloudy right lung base with obliteration of right heart border. *B*, lateral view of same patient. The distance from the ensiform to the nearest dorsal vertebra is 8.5 cm.

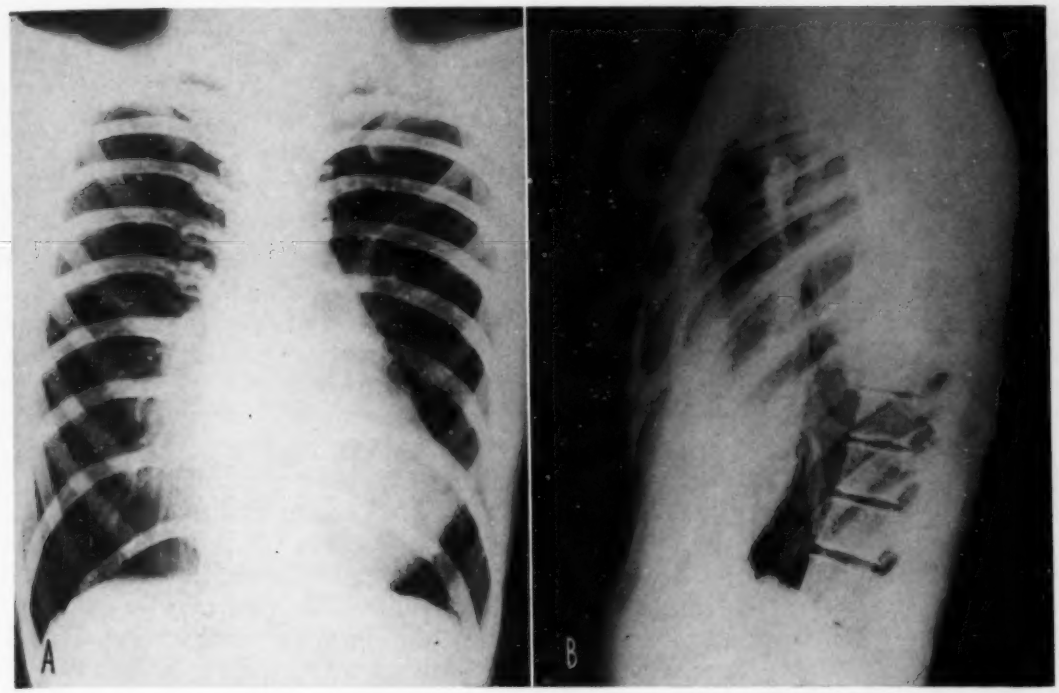

Fig. 3. *A*, posteroanterior and *B*, lateral views of another patient with a more severe funnel chest deformity. The heart shows a tendency toward a mitral silhouette. The cloudiness of the right medial lung base and indistinctness of the right cardiac border are illustrated.

is difficult to see due to compression of the adjacent lung.

(4) Decreased density of the heart shadow with corresponding increased visibility of the spine.[6]

(5) Cloudiness of the medial aspect of the right lung base. This is due to the increased mediastinal pleural space and to compression of the lung as a result of the depressed sternum. This may be sufficient to suggest atelectasis, pleural thickening or inflammatory consolidation. In the presence of the other findings listed, such cloudiness or lack of aeration at the right medial base should not be interpreted as evidence of disease unless examination of the patient or lateral views of the chest show no depression of the sternum.

SUMMARY

The clinical and anatomical aspects of funnel chest deformity have been described briefly. Attention is called to a number of changes which allow its recognition in the frontal projection of the chest, a necessity when examination is confined to this view, as is common in mass surveys. Of particular importance is the fact that the loss of aeration commonly present in the right medial base may be confused with such pathological conditions as atelectasis, pleural thickening, chronic inflammatory disease or consolidation. A recognition of the mediastinal displacement phenomena and the changed contour of the anterior arcs of the ribs will help to prevent such misinterpretation.

REFERENCES

1. Alexander J. Traumatic pectus excavatum. *Ann. Surg.*, 1931, *93*, 489–500.
2. Carr, J. G. Cardiac complications of Trichterbrust. *Ann. Int. Med.*, 1933, *6*, 885–894.
3. Edeiken, J. and Wolferth, C. C. The heart in funnel chest. *Am. J. M. Sc.*, 1932, *184*, 445–452.
4. Groedel, F. M. Das Verhalten des Herzens bei kongenitaler Trichterbrust. *München. med. Wchnschr.*, 1911, *58*, 684–686.
5. Ochsner, A., and DeBakey, M. Chone-chondrosternon; report of a case and review of the literature. *J. Thoracic Surg.*, 1939, *8*, 469–511.
6. Roesler, H. Clinical Roentgenology of the Cardiovascular System. Charles C Thomas, Springfield, Illinois, 1937, p. 148.
7. Sauerbruch, E. F. Quoted by Carr, ref. 2.

THE ROENTGENOLOGICAL STUDY OF ACUTE INFECTIONS IN THE RESPIRATORY TRACT OF CHILDREN

By JOHN S. BOUSLOG, M.D.
DENVER, COLORADO

FOR the past twenty years Dr. W. W. Wasson and I have been studying the sinuses and chests in children. We have come to the conclusion that the respiratory tract undergoes a progression of changes from birth to adult life as a result of normal growth and environment. Disease produces certain changes in these structures. These changes are often characteristic for each specific disease.

In the past fifteen years there has been a growing realization among medical men that many of the chronic and subacute diseases of the chest are dependent upon chronic or subacute infection of the nasal accessory sinuses. But I feel, even now, that there are comparatively few physicians who know how constant is this relationship. I believe that a large percentage of all cases of chronic tracheobronchitis, bronchitis, bronchiectasis, and peribronchitis are directly associated with some type of chronic sinus disease. Even when the lung disease occurs as a sequela of measles, whooping cough, scarlet fever, or influenza, it is probable that a sinus or mastoid disease exists in those patients when the trouble in the chest persists and is resistant to measures of relief directed to the chest itself.

In considerations of the respiratory tract, some have been accustomed to make frequent reference to the upper respiratory tract and the lower respiratory tract. It seems to me that some additional classification and nomenclature are required for a complete understanding and appreciation of the various interdependent and interrelated diseases that occur so frequently in the different divisions of the respiratory tract. It is impossible to dissociate one part of the respiratory tract from the other. The air passages are thought of as beginning at the vestibule of the nose and terminating in the pulmonary alveoli. Between these two points the tract is divided into anatomical and physiological divisions. The upper respiratory tract is considered as the nose, accessory sinuses, and pharynx. The mastoids are not mentioned by any authors, but I think they should be included in this tract. They do not directly aid in the preparation of the air for the lungs, but there is direct communication through the eustachian tube. Infection may reach the ear from the nasopharynx by this route. The lower respiratory tract consists of the trachea, bronchi, and the parenchyma of the lungs.

The pharynx has a specialized and distinct function setting it apart from the other two divisions. It is chiefly a mechanical one carried on by the sphincter action of the glottis which governs the quantity and pressure of the air intake.

Physiologically, each division of the respiratory tract plays a more or less independent rôle and has a somewhat dissimilar function to perform, but all function together. Their chief function is to facilitate the passage of the air to the alveoli. First, it has to be filtered and heated in the upper part of the respiratory tract to have it prepared for oxygenation of the blood and distributed to the tissues.

The lymphatic systems of these organs are connected, except that of the internal ear, which has no definite lymphatics. However, it has perilymphatic spaces which communicate with the subdural spaces of the cranium. The middle ear drains into the parotid nodes which communicate with the superficial cervical nodes. Mullin and Ryder[3] have demonstrated the connection of the lymph drainage of the upper air passages and accessory sinuses with the lungs.

Pfahler[4] demonstrated roentgenologically the lymphatic drainage from the maxillary sinuses to the thoracic duct in a case in which lipiodol had been injected in the maxillary sinuses. Therefore, the lymphatic system of the upper respiratory tract is associated with the lymphatics of the lower respiratory tract.

I believe a study of the mastoids, sinuses, and chests in all patients having acute infections of the respiratory tract would not only elicit a better understanding of the underlying pathologic processes but would also give a better interpretation of the presenting signs and symptoms and thus permit intelligent treatment of such patients.

I do not wish to give the impression that every acute infection involves all these various organs, but I do believe that the mastoids and sinuses are more frequently involved than is realized. It is only during the past few years that it has become common knowledge that a great majority of infants afflicted with severe gastrointestinal disturbances as the outstanding symptom also have accompanying foci of infection in the mastoids. Removal of these foci by means of antrotomies have given remarkable results in many cases showing no response to the usual medical regimen of treatment.

The effect of upper respiratory infection and the so-called focal infections in predisposing to or actually causing ulcer recurrences of the stomach is a fact which is acknowledged by most authors at the present time. Crohn and Shwartzman[1] make this statement:

"While unable to quote actual figures, we have always been convinced of the malign influence of tonsillar infections, acute naso-pharyngitis, grippe, influenza, pleurisy, and even pneumonia, bronchial and lobar, in activating ulcer recurrence. It has always seemed a hopeless cause to preserve an apparently healed ulcer case in the presence of a susceptibility to recurrent head colds or chronic sinusitis."

Quinn and Meyer[5] in 1929 introduced iodized oil into the nostrils of sleeping patients with a view of proving whether aspiration occurs in the lower respiratory tract. In 5 of 11 such patients there was direct evidence that the oil thus introduced was aspirated into the lung parenchyma or the bronchi with the greatest ease, and this occurred repeatedly in 2 individuals. In the other 6, lack of sound sleep vitiated the experiment. These authors observed that when the person lies on his side, ideal conditions exist for drainage of the antrum of the opposite side. If he lies on his back, drainage of both antrums is favored. A large majority of patients in question had maxillary sinusitis with frank pus associated with bronchiectasis. Dr. Carmody and I have never been able to get iodized oil to pass into the bronchi in harelip patients when the child was awake. We never have tried the experiment when the child was asleep.

In studying a disease of any given organ, one's attention is focused on that organ. We frequently do not think of the other organs associated with that system. These patients I have studied presented themselves at the Children's Hospital, Denver, Colorado, as acute infection of one of the divisions of the respiratory tract. The mastoids, sinuses, and lungs were studied in these cases which I wish to present.

CASE REPORTS

Case 1. G. G., Male, aged four. Previous history negative except for diphtheria, whooping cough, chicken pox and frequent attacks of otitis. The tonsils and adenoids had been removed five months before the present illness which began with malaise, fever and pain in the ears. Patient's appetite was poor, and he complained of slight abdominal pain at the onset. Pyelitis was suspected, but urinalysis was negative. Two days before admission the ear drums were incised and seropurulent discharge obtained. No tenderness over the mastoid region was present.

Physical Examination. Listless, colorless child, skin white. Temperature 103.8° F. There was a slight amount of nasal discharge, the throat was slightly swollen and inflamed, a very small amount of tonsillar tissue was present. Both ear drums were open and draining, the left was somewhat inflamed. There was some cervical adenitis. The lungs appeared clear and

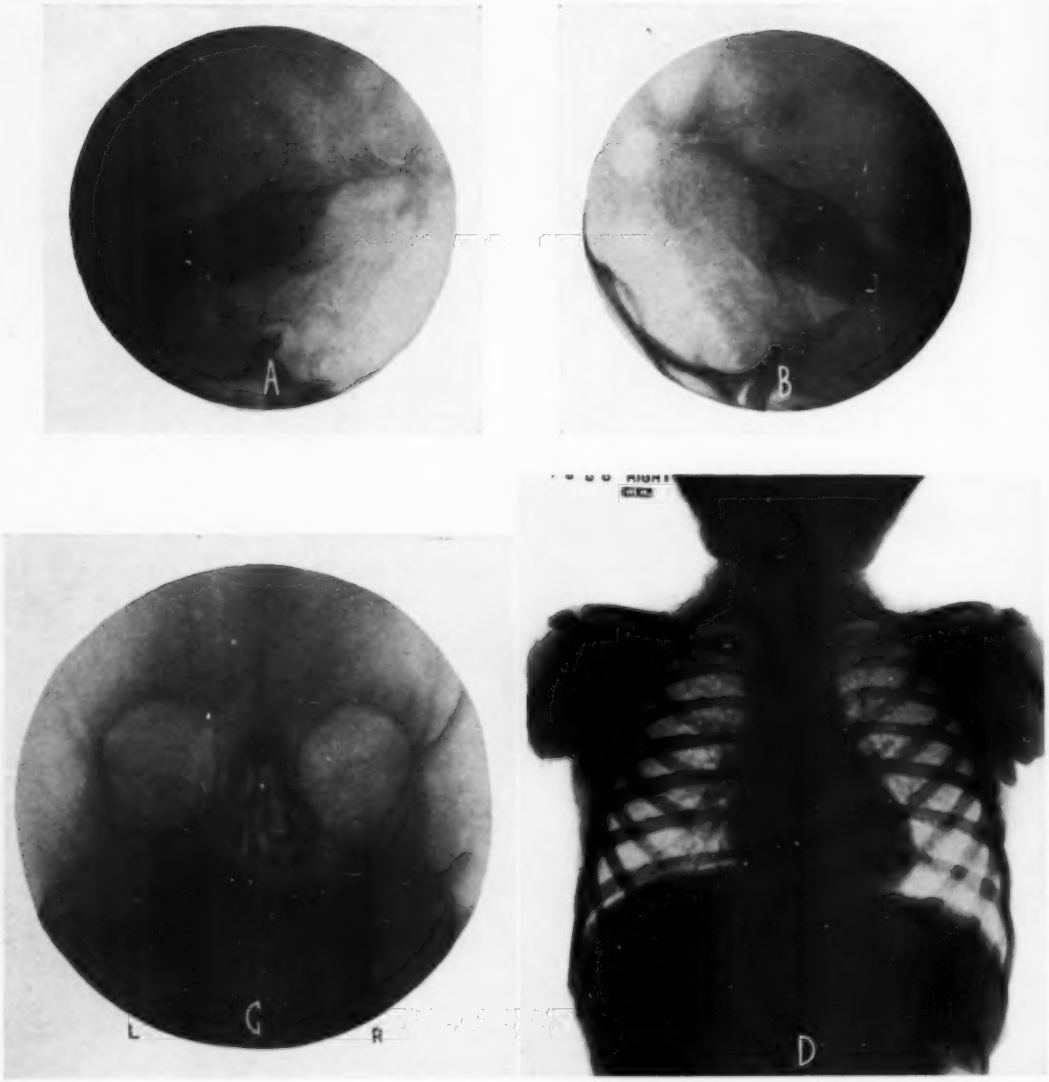

Fig. 1. Case 1. *A*, right mastoid; *B*, left mastoid; *C*, sinuses; *D*, chest.

the abdomen was negative. The diagnosis on admission was acute otitis media (bilateral) and acute pharyngitis.

Roentgenograms made the day of admission (Fig. 1) showed: Sinuses—pan-sinusitis with questionable retention in the antra. Mastoids—right mastoid of medium cell type with moderate congestion of the cells indicating moderate infection but no evidence of any breaking down of the septa. Left mastoid similar to right. Chest—some congestion at the hila which extended out along the bronchi and which was probably associated with an upper respiratory infection, but which was not a true bronchopneumonia.

Subsequent History. The patient's temperature dropped to normal the next day, and three days later he was sufficiently improved to be discharged from the hospital.

Case II. F. S., Male, aged three.

Previous History. At the age of four months, the patient was hospitalized for feeding regulation. Two and one-half years previous to this illness he had similar trouble and was never robust or healthy after that. Two weeks previous to admission he had bronchopneumonia, from which he apparently recovered. The temperature had returned to normal. Five days before admission the temperature rose again and otitis media developed. Both ear drums were incised three days before admission but although the

ears discharged freely, the daily rise in temperature persisted.

Physical Examination. Pale, poorly nourished child of three years who did not appear acutely ill. There was serous nasal discharge and posterior pharyngeal congestion. Both ears were tender, the canals were injected, and the left was draining serous exudate. There was some posterior cervical adenitis. Lungs and abdomen appeared negative. The diagnosis on admission was acute otitis media (bilateral).

Roentgenograms made the day before admission showed: Sinuses—moderate infection of the right antrum and right ethmoids with questionable retention in the antrum. Slight infection of the left antrum and left ethmoids. Mastoids—both of medium cell type, left appeared negative. In the right there was some congestion of the cells in the antrum indicating some infection, but there was no evidence of any breaking down of the septa. Chest—some congestion of the hila extending out along the bronchi and indicating an acute infection but not a true bronchopneumonia.

Subsequent History. In spite of every form of treatment, the patient continued to have high temperature. His appetite was poor, and he was apathetic. Five days after admission, the sinuses, mastoids, and chest were checked roentgenographically (Fig. 2). The sinuses and mastoids were practically the same as in the former examination, but the chest showed slightly more congestion of the bronchi, especially in the right base. This had the appearance of bronchopneumonia. The following day the patient received 100 cc. of whole blood transfused directly from the donor (mother). Four days after that he began to improve and con-

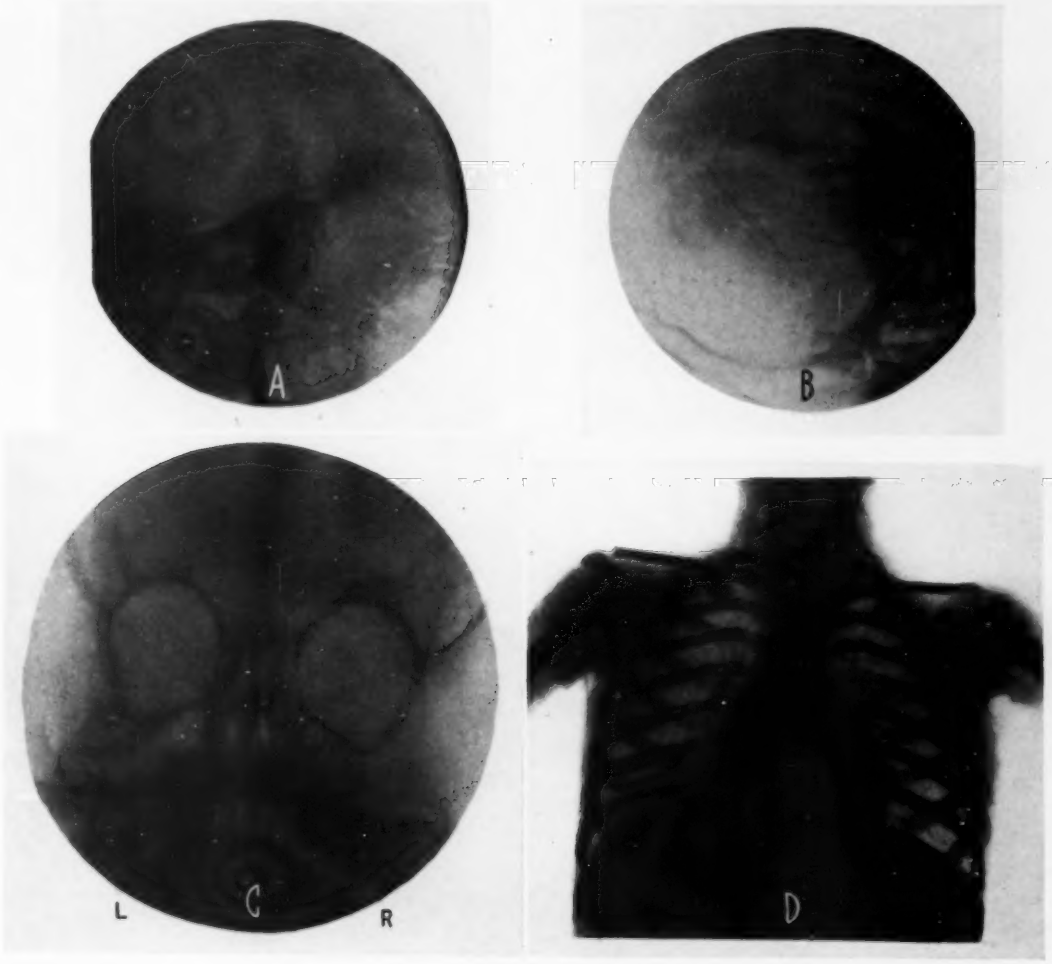

Fig. 2. Case 11. *A*, right mastoid; *B*, left mastoid; *C*, sinuses; *D*, chest.

tinued to do so until he was discharged six days later (twelve days after admission).

Case III. D. H., Male, aged seven months.

Previous History. Since the age of two months the patient had had rash on his body. For the two weeks immediately preceding admission to the Children's Hospital, Denver, he was hospitalized elsewhere, where for the latter week he experienced difficulty in breathing and had high temperature.

Physical Examination. Fairly well developed male infant. The nose was injected, tongue coated, the pharynx congested and there seemed to be much mucus. The tonsils and right ear were inflamed. There were râles throughout both lungs, especially in the bases, and breath sounds were markedly exaggerated. The abdomen was negative except for the macular rash which was over it. The rash extended over the chest, back and neck, The diagnosis on admission was bronchopneumonia, acute right otitis media, acute pharyngitis and tonsillitis, and infantile eczema.

Roentgen examination nine days after admission (Fig. 3) showed: Sinuses—moderate density of the antra, slight density of the right and left ethmoids indicating a moderate infection of these sinuses without any evidence of retention. Mastoids—left mastoid had not begun to develop, there was one cavity and no evidence of any congestion; the right mastoid was

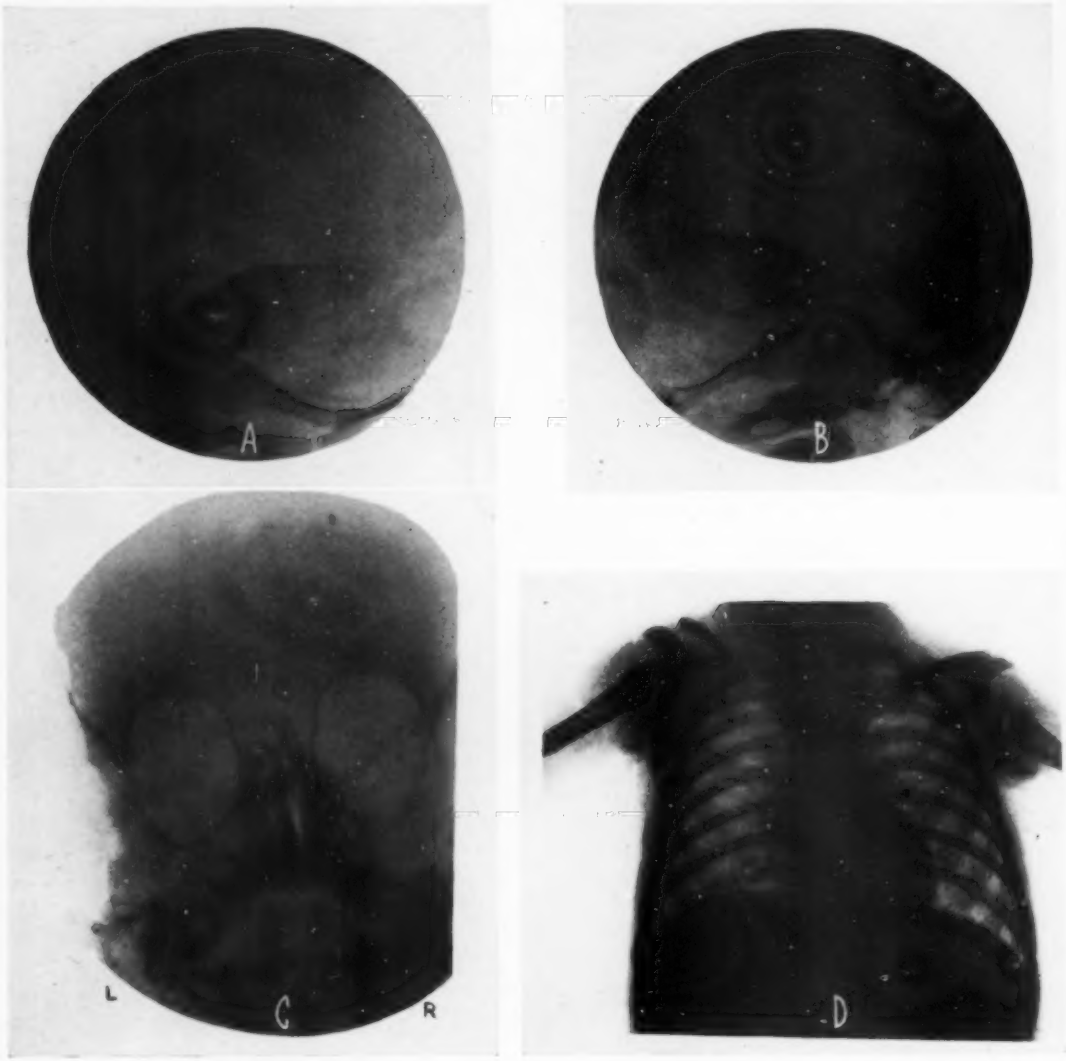

Fig. 3. Case III. *A*, right mastoid; *B*, left mastoid; *C*, sinuses; *D*, chest.

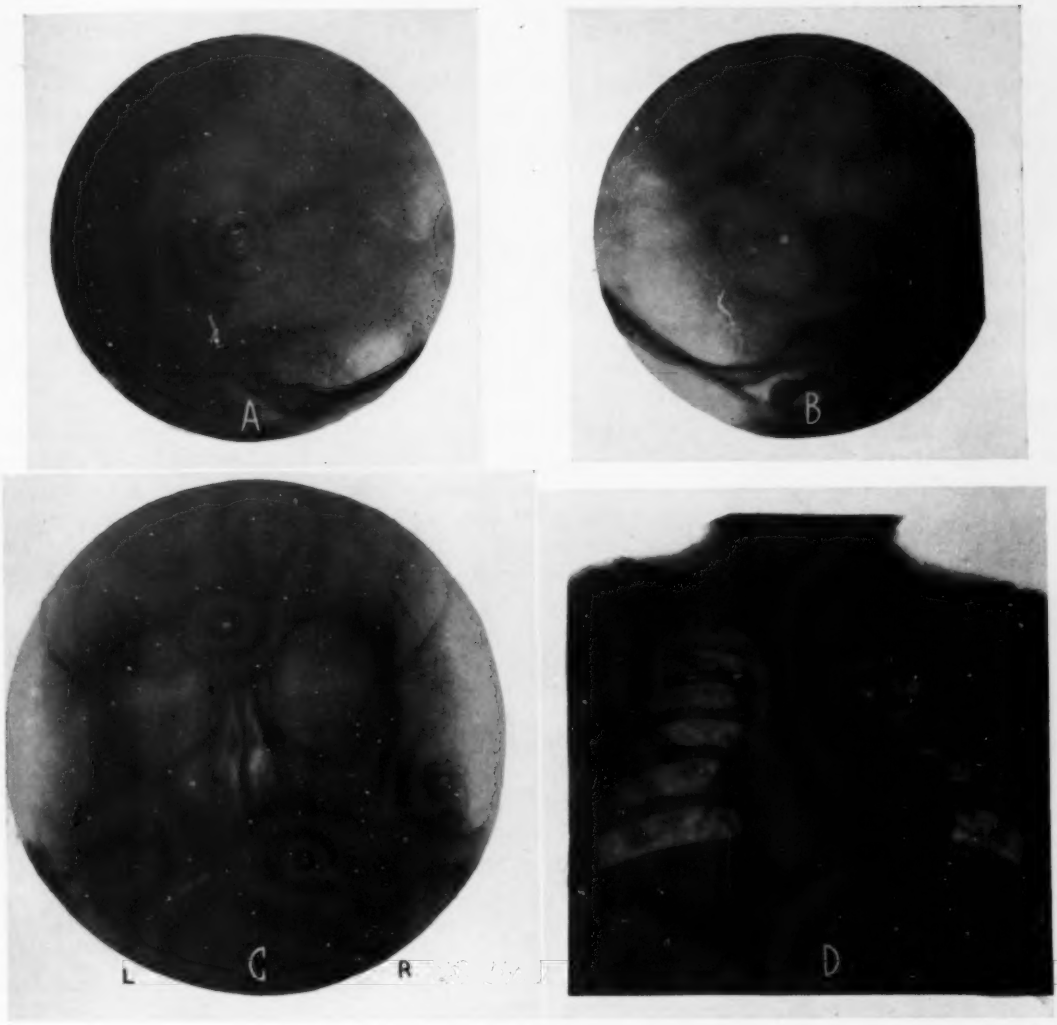

Fig. 4. Case iv. *A*, right mastoid; *B*, left mastoid; *C*, sinuses; *D*, chest.

similar to the left. Chest—some congestion of the bronchi extending out from the root of each lung, slightly more marked in the right upper lobe, which indicated acute infection but not definitely a bronchopneumonia.

Both the Mantoux and Wassermann tests gave negative results.

Subsequent History. Patient improved for two weeks, then the temperature rose to 103.2° F., the right ear stopped draining, there was much mucus, and the skin was slightly dehydrated. The temperature remained high, and on the nineteenth and thirty-ninth days after admission transfusions of 60 cc. each of citrated blood were given. After the second transfusion there seemed to be slight improvement until six weeks later when the temperature rose again and a few râles appeared in the lungs. The following day there were several cyanotic attacks, the chest was filled throughout with râles, the pulse was weak and rapid, and there was much dyspnea. Thereafter the temperature rose rapidly and steadily to 108° F. and the child died (two months and two days after admission). The necropsy diagnosis was erythroedema, disseminated bronchopneumonia. The sinuses and mastoids were not examined.

Case iv. E. H., female, aged two.

Previous History. Aside from measles and otitis one year previously, the patient had been in good health until nine months previously when she suddenly broke out with what appeared to be hives during a scarlet fever epidemic. There were no throat symptoms, she had a slight rise in temperature, but the eruptions disappeared

in three days and none of her brothers or sisters became ill. Three months later a doctor was consulted because of swelling of the feet. The urine then showed a 4 plus albumin reaction, which persisted. For the two months previous to hospital admission, she had puffiness of the eyes, and some swelling of the abdomen (ascites).

Physical Examination. Well developed girl with a marked general edema, especially of the eyelids. The tongue was coated, the tonsils slightly injected and the ears were negative. In the chest, there were a few râles in the base posteriorly but no dullness. The abdomen was distended and dull to percussion. The knee jerks were not obtained. The diagnosis on admission was nephrosis with ascites.

Course. Three days after admission the patient had severe bronchitis; three days later she was given 150 cc. of whole blood direct from the donor, and on the eighth day after entering the hospital she received 175 cc. of citrated blood. Following this the edema cleared and on the tenth day after admission she was given 50 cc. of blood serum.

Roentgenograms made the sixteenth day after admission (Fig. 4) showed: Sinuses—frontals not developed; right antrum dense, the left only moderate density; right and left ethmoids moderately dense indicating moderate infection. Questionable retention in the right antrum. Mastoids—practically no cells showing in the right mastoid, but a moderate density in the antrum and around the auditory canal which had the appearance of an undeveloped mastoid with some eburnation due to chronic infection. The left mastoid was similar to the right. Chest—some increased fibrosis at the root of each lung and extending out along the bronchi into each lung especially the base, which indicated a pulmonary infection, and which was probably associated with an upper respiratory infection.

Subsequent History. The patient was in the hospital for six weeks after the roentgen examination. During that time, the temperature returned to normal, tonsils and adenoids were removed, two more transfusions were given, one week, and ten days after the operation, and the patient improved although her weight fluctuated. The nephrosis improved but the urine did not entirely clear, and the temperature was 99.6° F. when she was discharged two months and three days after admission.

Case v. N. S., female, aged one and a half. Previous history was negative except for attacks of tonsillitis and adenitis. Two weeks previous to admission she had a streptococcic infection of the gums. Three days before admission the patient began to have sore throat, high fever, and loss of appetite, even refusing fluids.

Physical Examination. On admission the patient's skin was clear and dry, there was some nasal discharge, the throat was red, edematous and patchy, the tonsils were enlarged and congested, and there was bilateral cervical adenitis. The lungs and abdomen were negative. The diagnosis on admission was streptococcic sore throat with possible pharyngeal abscess.

The chest was roentgenographed the day of admission (Fig. 5) and showed slight congestion of the bronchi in the right base, but not a definite bronchopneumonia. Four days later the sinuses and mastoids were examined roentgenologically. Sinuses—considerable density of the right antrum, slight density of the left; moderate density of the right and left ethmoids. Conclusions: moderate infection of the sinuses with questionable retention in the right antrum. Mastoids—the left mastoid was of the medium cell type with slight congestion of the cells in the antrum indicating a slight infection, but no evidence of any breaking down of the septa. The right mastoid was similar to the left.

Laboratory Examination. Blood culture showed a growth of *Streptococcus haemolyticus.*

Subsequent History. The temperature ran a septic course; two days after admission a transfusion of 100 cc. of whole blood was given, the ears became involved and the left drum ruptured spontaneously but the right was incised. After three weeks the temperature fell by lysis, and the patient was discharged five weeks after admission. One week later the patient was readmitted for removal of tonsils and adenoids, and made an uneventful recovery.

Case vi. J. M., Male, aged three and a half.

Previous History. Patient had croup, scarlet fever, tonsillitis and adenitis. Measles developed fourteen days before admission and patient was quite ill. Five days later he developed cough, temperature rose to 104.5° F., and a small pneumonic area was diagnosed in the left lung. The temperature fluctuated up and down, and four days previous to admission a pneumonic area was noted on the right side. The temperature rose higher and the child became delirious.

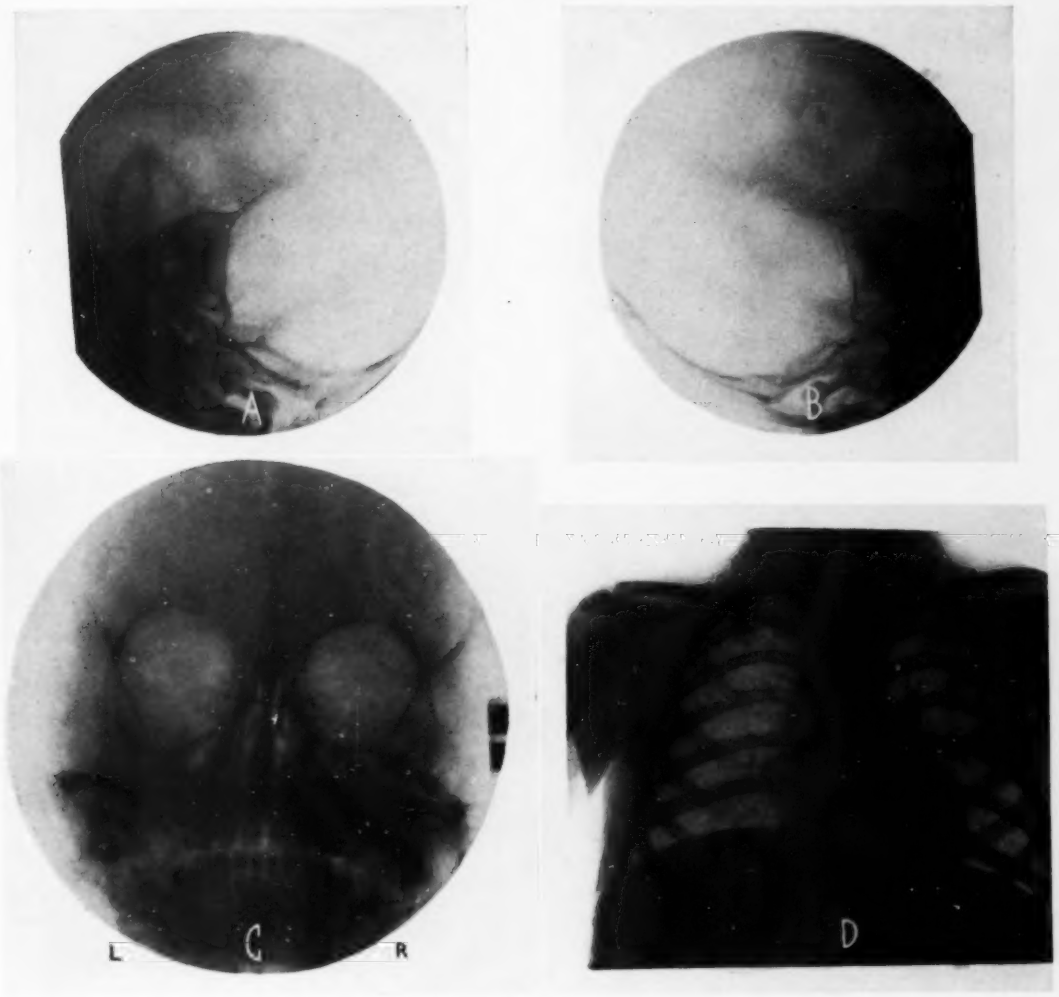

Fig. 5. Case v. *A*, right mastoid; *B*, left mastoid; *C*, sinuses; *D*, chest.

Physical Examination. On admission the throat was red and injected, tonsils large and red, there was slight enlargement of the cervical glands, the ears were negative. The measles rash on the abdomen was fading. There were many râles in the left lung and it was slightly dull to percussion. The patient had a slight cyanotic attack the day he was admitted. The following day both ears were inflamed, and one week later râles developed in the right upper lobe and there was definitely fluid in the left base.

Roentgenogram of the chest was made four days after admission (Fig. 6). This showed a pneumonic area in the right upper lobe and one in the left lower lobe. There was some congestion of the bronchi in the right base and left upper lobe. One week later the chest was again roentgenographed, and again nine days later. The sinuses and mastoids were examined twenty-five days after admission. When the chest was re-examined the second time, the pneumonic area in the right upper lobe was undergoing resolution. There was some increased density over the left base indicating fluid.

The examination of the sinuses and mastoids showed a slight density of the antra, moderate density of the right and left ethmoids indicating moderate infection of the sinuses without any evidence of retention. The left mastoid was of the medium cell type, there was slight congestion of the cells in the antrum which indicated slight infection but there was no breaking down of the septa. The right mastoid was the same type as the left, there was moderate

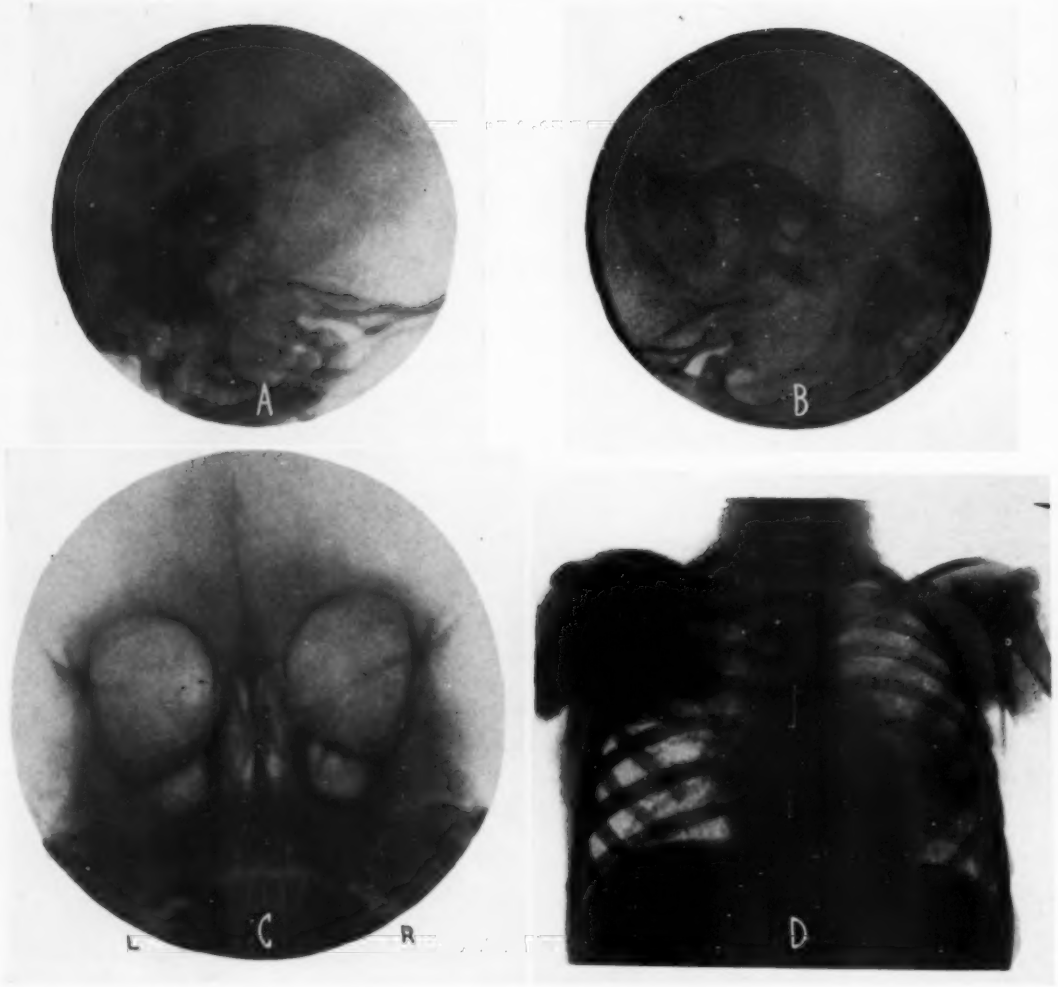

Fig. 6. Case vi. *A*, right mastoid; *B*, left mastoid; *C*, sinuses; *D*, chest.

congestion of the cells in the antrum and apparently slight thinning of the septa which indicated acute mastoiditis.

Subsequent History. Seven days after admission, the child developed empyema of the left lung which necessitated draining. The ears flared up once but the condition cleared without surgical intervention. Once the temperature rose, but that may have been due to toxoid which was given the child. There was considerable improvement when the patient was discharged one and one-half months after admission.

Case vii. R. K., male, aged seven and a half.

Previous History. Patient had congenital harelip and cleft palate. He had been operated on at the age of three weeks, but failed to return for further treatment. Had croup, measles and German measles, tonsillitis and adenitis. The reason for admission to the hospital at the time reported here was for further surgery on the lip and palate. The physical examination was negative.

Course. Four days after operation (seventeen days after admission) the patient began to have fever, which rose to 104° F., and for which no cause could be found. He complained of abdominal pain but there was no localized tenderness, and examination at that time was essentially negative. Ten days later both ear drums were inflamed, and the right one ruptured and began draining. One week later the left drum was incised.

Roentgenograms made six days after operation (Fig. 7) showed: Sinuses—right frontal was very small, in fact nothing more than a high

anterior ethmoid cell. The left frontal was small also, the other sinuses were of average size for a child of that age. There was slight density of the antra and right and left ethmoids indicating slight infection of these sinuses. Mastoids—right mastoid showed only a few cells high in the antrum, there was considerable density around the auditory canal and in the mastoid down toward the tip. The lateral sinus swung fairly well forward indicating an undeveloped mastoid with eburnation from chronic infection. The left mastoid showed some cells in the anterior and posterior part and extending down toward the tip. There was considerable density around the auditory canal and in the antrum extending down toward the tip. Some thickening of the septa in the posterior cells indicated a chronic infection with eburnation. Chest—there was a slight thickening of the pleura between the right upper and middle lobes. Moderate increased fibrosis at the root of each lung and extending out along the bronchi into each lung indicated a pulmonary infection which was probably associated with an upper respiratory infection. There was no evidence of lung abscess or central pneumonia.

Subsequent History. After myringotomy, both ears drained for some time, the discharge gradually decreased and the temperature became normal for a time although on the date of discharge (seven weeks after admission) it was 99° F.

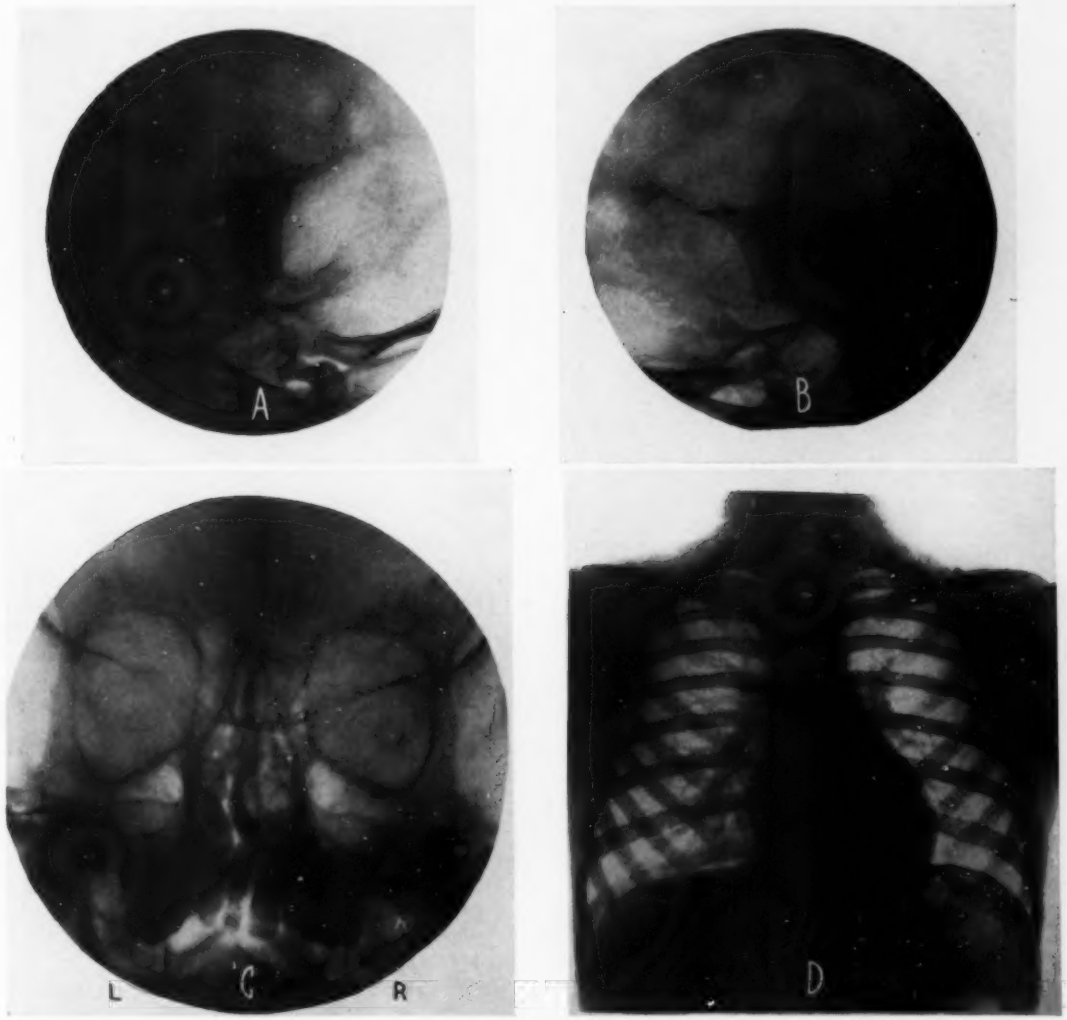

FIG. 7. Case VII. *A*, right mastoid; *B*, left mastoid; *C*, sinuses; *D*, chest.

Case VIII. E. C., male, aged eleven and a half.

Previous History. Patient had many sore throats and began to become deaf; tonsils and adenoids removed at the age of five. Following the operation improvement was rapid, the patient gained weight and the deafness disappeared. At the age of nine and a half he began having ear aches again; these gained in frequency and severity and were accompanied by slight deafness. One week previous to admission patient developed fever which subsided at night and rose as high as 104° F. during the day. Three days later began to have discharge from right ear.

Physical examination on admission was negative except for the right ear which was draining; there was no mastoid tenderness. The diagnosis on admission was acute suppurative otitis media.

Roentgenograms made on admission (Fig. 8) showed: Sinuses—the right antrum was dense, and there was moderate density of the left. There was slight density of the right and left ethmoids. These findings indicated moderate infection of the ethmoids and antra with questionable retention in the right antrum. Mastoids—the left mastoid was of the medium cell type and negative. The right was not as well developed as the left, medium cell type, and considerable density around the auditory canal and moderate thickening of the septa in the antrum and extending down toward the tip indicated a chronic infection. Chest—there was a pneumonic area at the hilum which involved the right middle lobe. There was slight conges-

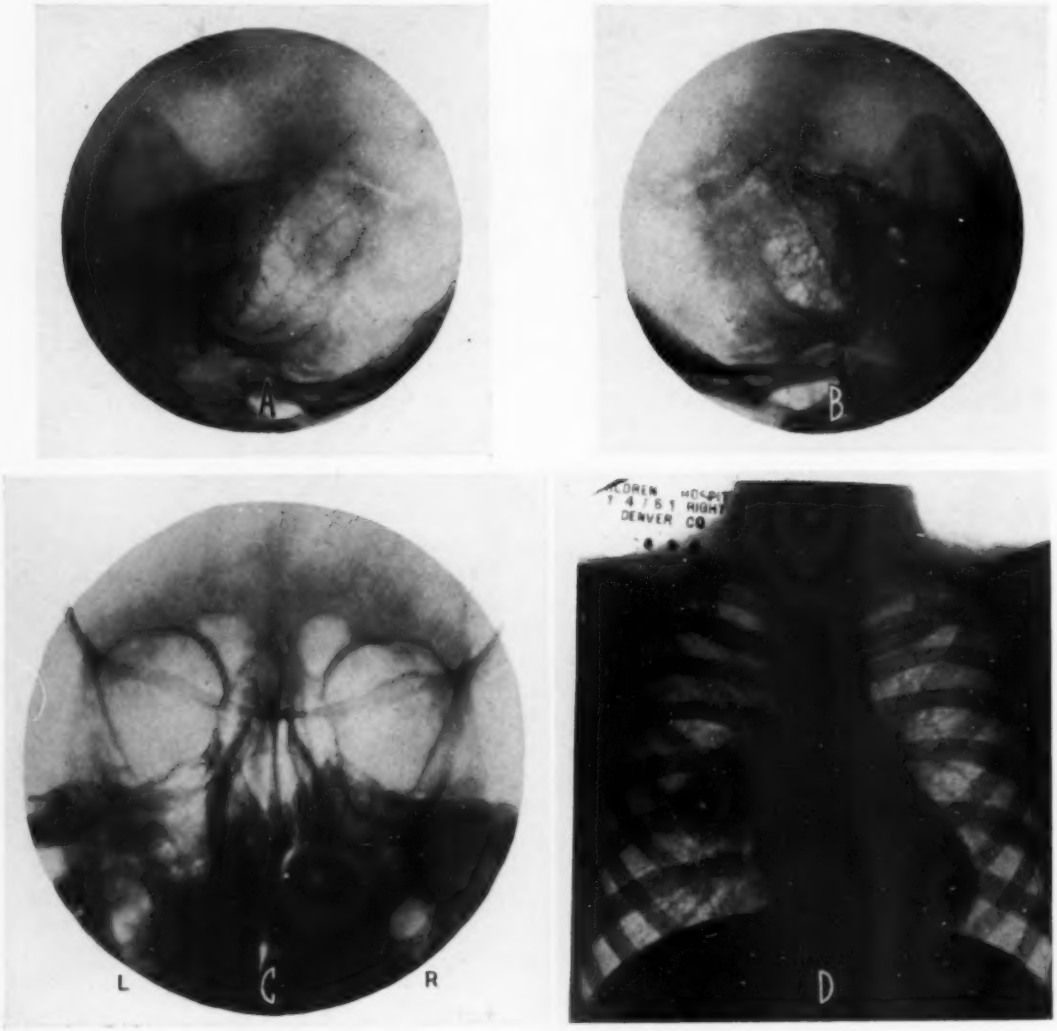

Fig. 8. Case VIII. *A*, right mastoid; *B*, left mastoid; *C*, sinuses; *D*, chest.

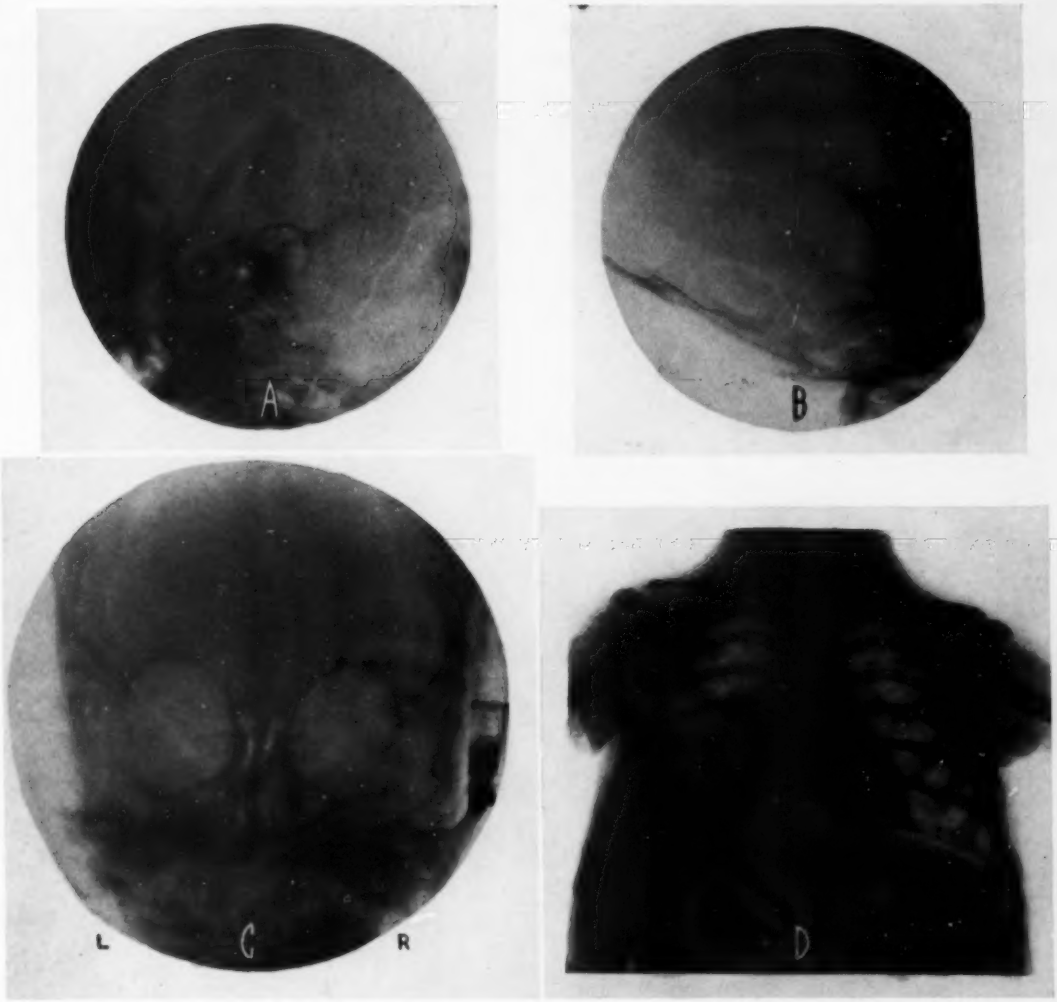

Fig. 9. Case ix. *A*, right mastoid; *B*, left mastoid; *C*, sinuses; *D*, chest.

tion of the bronchi in the right base. The left lung was quite clear.

Subsequent History. Ten days after admission, tonsil and adenoid tags were removed. After that he showed continual improvement until discharged from the hospital two weeks later.

Re-admission. Three months later the patient was re-admitted because nine days previously, after receiving a blow on the face and nose, he began to have a rise in temperature which varied between 99 and 100° F. After that temperature varied from 100 to 105° F. He had several chills, and headaches, severe and continuous and general in location, but no other appreciable complaints.

Physical examination was negative except that transillumination of the sinuses showed mild cloudiness. The diagnosis on admission was pan-sinusitis.

Subsequent History. The day after admission, he began to cough and complained of pain in his chest. Examination then revealed slight change in breath sounds. Roentgen examination of the sinuses showed a slight infection of the antra. The check examination of the chest showed a pneumonic area of the lobar type in the right upper lobe. The patient developed interlobar effusion which absorbed, and he was discharged well ten days later.

Case ix. S. B., female, aged eight months. The previous history was negative until four weeks previously when she developed a nasal discharge, slight cough, and fever for two days. Recovery was complete. Three days before admission the patient developed fever, cough, wheeziness, and respiratory grunt. There were no convulsions, but the day before admission she vomited and was very restless.

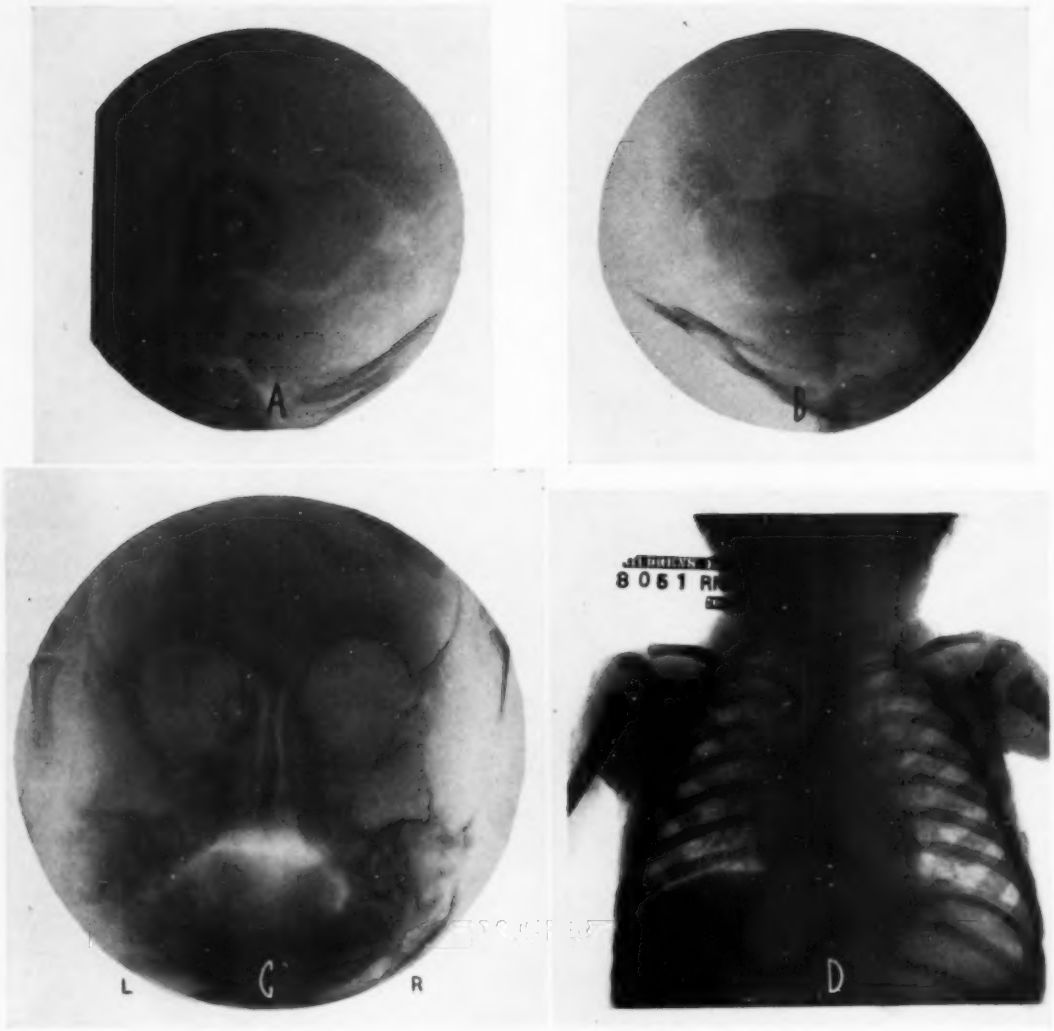

Fig. 10. Case x. *A*, right mastoid; *B*, left mastoid; *C*, sinuses; *D*, chest.

Physical Examination. Temperature 104.5° F., there was no nasal discharge, tonsils were large and red, the left ear drum was reddened, but there was no discharge from the ears. Otherwise the examination was negative. The diagnosis on admission was acute upper respiratory infection, and acute left otitis media.

Roentgenograms made the following day (Fig. 9) showed: Sinuses—the frontals were not developed, the right and left ethmoids and antra were dense, indicating considerable infection with probable retention in the antra. Mastoids—the right mastoid was negative, and there was no definite cell development. The left showed no definite cell development. There was some cloudiness in the region of the antrum indicating some infection. Chest—there was a pneumonic involvement of the right lower lobe, and slight congestion of the bronchi in the right upper lobe. There was a slight congestion at the root of the left lung.

Subsequent History. Two days after admission a few moist and dry râles were found at the level of the mid portion of the right scapula near the spinal column which gave the impression of right central pneumonia. Four days after admission the left ear drum was incised and pus was obtained, a culture of which showed pneumococcus infection. The patient developed interlobar effusion between the right middle and lower lobes. This cleared and the patient was discharged after eighteen days in the hospital.

Case x. N. T., male, aged five and a half months.

Previous History. Ever since a few days old the patient vomited his food, and was very "nervous." In the hospital where he was born this condition had been controlled by medication, but it returned when the patient was taken to his home. He had been artifically fed from the time of birth because the mother was toxic. Patient slept fitfully, and often cried out while sleeping, at times perspiration stood out on the head and he acted as if in severe pain. This continued day and night, but the baby continued to gain weight fairly well.

Physical Examination. Aside from slight congestion in the throat the examination was negative and nothing could be found to account for his crying. The Mantoux test was negative.

Course. Five days after admission temperature rose to 104° F., both ear drums were congested, and they were incised. Thereafter the temperature gradually subsided to normal on the tenth day. Nine days later there was a repetition of the temperature flare-up, and at that time there was a thick purulent discharge from the left ear and some bulging of the posterior canal. Four days later the temperature rose to 106° F. and the patient developed symptoms of meningeal irritation.

Roentgenograms made at that time (Fig. 10) showed: Sinuses—the frontals were not developed, the antra were dense and there was moderate density of the right and left ethmoids, indicating considerable infection of these sinuses with probable retention in antra.

Mastoids—in the left mastoid the cells had not begun to develop; there was one cavity and it was negative. The right mastoid showed some congestion of the mastoid cavity which indicated a slight infection. Chest—there was slight increased fibrosis of the hila extending out along the bronchi which indicated a slight pulmonary infection which was probably associated with an upper respiratory infection.

Subsequent History. The next day, bilateral myringotomy was performed and a transfusion of 100 cc. of whole blood was given direct from the donor (mother). The spinal fluid was negative. Three days later the patient developed a marked cervical adenitis especially on the left side, but the temperature gradually subsided. Ten days later the temperature rose again and another bilateral myringotomy was done. Again the temperature subsided, but the left cervical adenitis persisted. Forty-eight days after admission a posterior lateral pharyngeal abscess was incised and four days after that the left cervical glands were incised and drained. Two days later both antra were irrigated, and the patient was given a second transfusion, this time of 120 cc. of citrated blood. Following the transfusion, he began to improve rapidly and to gain weight. He was discharged two weeks after the second transfusion in good condition.

CONCLUSIONS

From these case histories I have tried to exemplify the following conclusions:

1. Frequently there may be acute infection in another division of the respiratory tract which is more serious than the infection in the part that has produced the apparent symptoms.

2. Examination of all divisions of the respiratory tract will frequently elicit the cause of prolonged illness and otherwise unexplainable symptoms which are sometimes encountered.

3. Early accurate diagnosis of such acute infections and proper treatment may prevent many chronic diseases of adult life.

REFERENCES

1. Crohn, B. B., and Shwartzman, G. Ulcer recurrences attributed to upper respiratory infection; possible illustration of the Shwartzman phenomenon. *Am. J. Digest. Dis. & Nutrition*, 1938, *4*, 705–707.
2. Mulligan, H. R. Mastoiditis in infants associated with gastro-intestinal symptoms. *Ann. Otol., Rhin. & Laryng.*, 1932, *41*, 501–512.
3. Mullin, W. O., and Ryder, C. J. Studies in lymph drainage of upper air passages and accessory sinuses. *Laryngoscope*, 1921, *31*, 158–178.
4. Pfahler, G. E. Demonstration of lymphatic drainage from maxillary sinuses. Am. J. Roentgenol. & Rad. Therapy, 1932, *27*, 352–356.
5. Quinn, L. H., and Meyer, O. O. Relationship of sinusitis and bronchiectasis. *Arch. Otolaryng.*, 1929, *10*, 152–165.
6. Settel, N. Systemic complications in sinusitis. *Laryngoscope*, 1934, *44*, 398–406.
7. Wasson, W. W. Infection of respiratory tract in infant and child. *Texas State J. Med.*, 1927, *22*, 623–626.
8. Wasson, W. W. Developmental study of nasal accessory sinuses. *Radiology*, 1927, *8*, 398–408.
9. Wasson, W. W. Incipiency of disease. *Radiology*, 1929, *13*, 29–35.
10. Wasson, W. W. Bronchosinusitis disease. *J. Am. M. Ass.*, 1929, *93*, 2018–2021.

CINEROENTGENOGRAPHIC DIAGNOSIS OF CONGENITAL AND ACQUIRED HEART DISEASE*

By W. H. STEWART, M.D., CHARLES W. BREIMER, M.D., *and* HERBERT C. MAIER, M.D.
Lenox Hill Hospital
NEW YORK, NEW YORK

THE making of motion pictures of the image present on the fluoroscopic screen is known as cineroentgenography. This procedure is especially suitable for demonstrating lesions of the intrathoracic organs. With the aid of contrast media it is possible to delineate the large vessels and cardiac chambers, the esophagus and the tracheobronchial tree. Motion of these structures may also be graphically demonstrated. These motion picture films may be used for the study of physiological and pathological processes, and for teaching purposes.

Cineroentgenography has now developed to a point where one can obtain satisfactory films in most instances. The apparatus and technique have been adequately described elsewhere.[1] The purpose of this article is to enumerate applications of the method in cardiovascular diagnosis and to report several cases in which cineroentgenography has contributed additional information to that obtainable by ordinary roentgen examination.

The use of contrast media for the visualization of the heart and great vessels was devised by Robb and Steinberg. This technique is a remarkable contribution to roentgen diagnosis of the circulatory system. With this method we have made cineroentgenographic studies of the pulmonary circulation, cardiac chambers and great blood vessels. The identical technique of Robb and Steinberg[2] has been followed. By the rapid intravenous injection of 30 to 40 cc. of 70 per cent diodrast a portion of the blood stream is rendered temporarily radiopaque. The opacified blood may be followed from the site of injection in the arm through the great veins to the right side of the heart. The right auricular and ventricular chambers are visualized and the outlines of the pulmonary artery clearly demonstrated. Then this opaque column of blood, returning through the pulmonary veins, delineates the chambers of the left auricle and ventricle and finally outlines the aorta.

This entire sequence recorded on a strip of motion picture film makes it possible to study the vascular anatomy, physiology and pathology in a much more complete manner than formerly when merely two roentgenograms were made during the brief period that the heart chambers and great vessels were opacified. Cineroentgenographic recordings of this sort are of particular value in the study of congenital heart disease. Visualization of the entire cycle of the opacified blood through the heart and great vessels enables the detection of certain abnormalities in blood flow, and in vascular and cardiac outlines which may escape observation if only two roentgenograms are made. Detail of structure, however, cannot be as clearly visualized by cineroentgenography as by roentgenograms. The two methods supplement one another.

The diagnosis of the exact nature of a congenital cardiac lesion by physical signs is often difficult or impossible. The ordinary roentgenogram is of only limited aid in most cases of congenital heart disease. A few typical cases examined by cineroentgenography during opacification illustrate the possibilities of this method.

Case 1. Male, aged fourteen, had been dyspneic and cyanotic since birth. The child was underdeveloped both physically and men-

* Read at the Forty-first Annual Meeting, American Roentgen Ray Society, Boston, Mass., Oct. 1–4, 1940.

tally. There was marked clubbing of the fingers. Physical examination revealed an enlarged heart with a loud systolic murmur at the apex and pulmonic area, and a systolic thrill over the apex. The blood pressure was 80/60. The electrocardiogram showed right axis deviation.

A roentgenogram of the chest showed notching of the under surface of the upper ribs suggesting coarctation of the aorta. The whole clinical picture, however, could not be explained by that diagnosis.

The cineroentgenographic studies after the injection of diodrast showed that the opacified blood passed in a normal manner as far as the right ventricle. From here the opaque blood passed simultaneously into the pulmonary arteries, aorta, and, through a defect in the interventricular septum, into the left ventricle. This flow of opacified blood through the septum from right to left could be easily identified in the motion picture. The aorta was clearly outlined and showed no coarctation (Figs. 1*A*, 1*B* and 1*C*).

Case II. Male, aged seven, had a history of progressive cyanosis since the age of one month. The child's development had been fairly good and dyspnea was not prominent. Marked clubbing of the fingers and toes was present. On physical examination the heart was considerably enlarged. There was a systolic thrill with a harsh systolic murmur at the apex. The blood pressure was 105/90. The electrocardiogram showed right axis deviation. The clinical diagnosis was tetralogy of Fallot. Pathologically, this condition shows four characteristic abnormalities: (1) right ventricular enlargement,

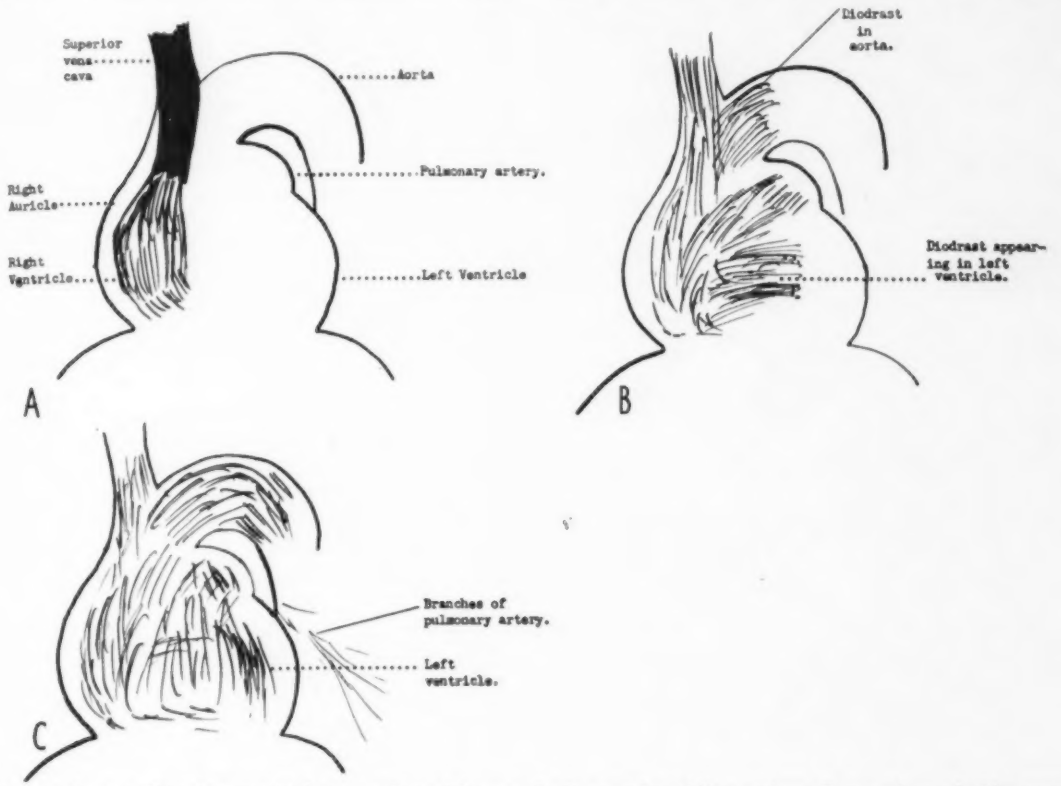

Fig. 1*A*. Case 1. Tracing made from projected image. Left anterior oblique view. One and one-half seconds after injection. Tetralogy of Fallot. The diodrast (black) is seen solidly filling the superior vena cava and entering the right auricle and right ventricle.

Fig. 1*B*. Case 1. Two and one-half seconds after injection. The aortic arch, pulmonary artery and region of the left ventricle show opacification indicating an interventricular septal defect and communication of the aortic origin with the right ventricle.

Fig. 1*C*. Case 1. Four and one-half seconds after injection. Diodrast has filled the left ventricular cavity, aortic arch and descending aorta, the pulmonary artery and its branches. At this time diodrast would not normally have reached the left ventricular cavity.

(2) pulmonary stenosis, (3) interventricular septal defect and (4) dextra position of the aortic orifice which rides over the defect in the interventricular wall.

Cineroentgenographic contrast studies showed the opacified blood progressing normally to the right auricle and then into the right ventricle which was somewhat enlarged. Immediately after entry of the diodrast into the right ventricle simultaneous opacification occurred in the pulmonary artery, the left ventricle and the aorta. The aorta was larger than normal, and considerably larger than the pulmonary artery. The findings are what one would expect from the type of pathology in a tetralogy of Fallot and confirmed the clinical impression (Figs. 2*A*, 2*B* and 2*C*).

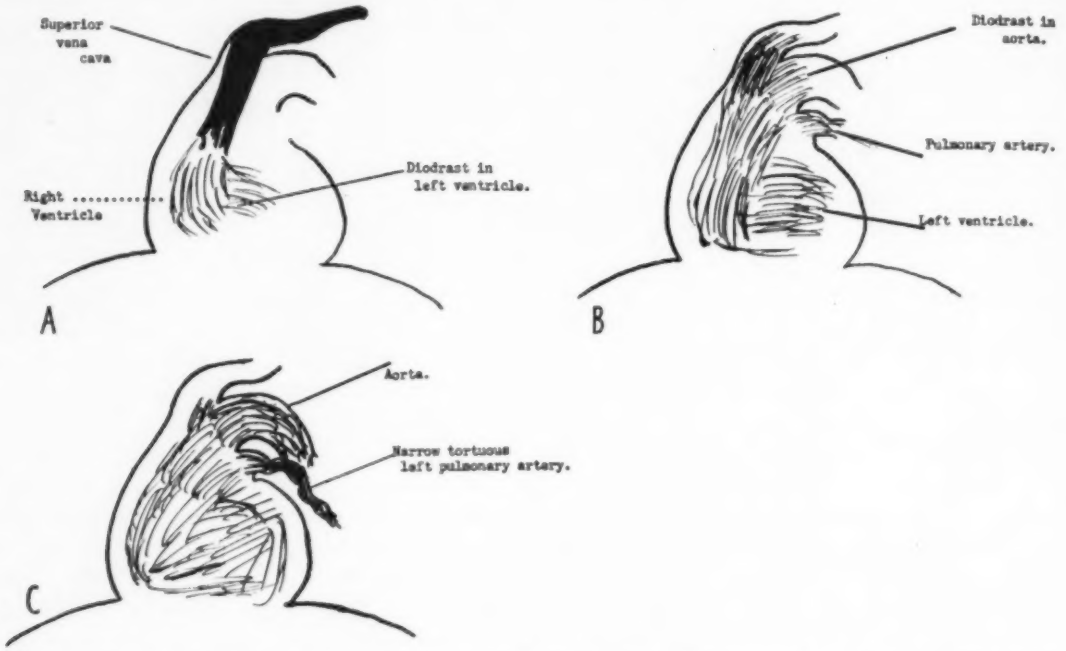

FIG. 2*A*. Case II. Tetralogy of Fallot. Left anterior oblique position. One and one-half seconds after injection. Diodrast is seen solidly filling the superior vena cava. Some of it has reached the right ventricle and is beginning to appear in the left ventricle through the patent interventricular septum.

FIG. 2*B*. Case II. Two and one-half seconds after injection. The diodrast is seen to enter the left ventricular cavity in a great wave, indicating a large interventricular septal defect. Diodrast is also present in the ascending aorta indicating communication of aorta with the right ventricle. The pulmonary artery also contains diodrast.

FIG. 2*C*. Case II. Three and one-half seconds after injection. The aorta, left pulmonary artery and entire aortic arch contain diodrast. The left pulmonary artery is seen to be narrow and tortuous. The aorta is dilated.

CASE III. The patient was a male, aged twenty-two, with a history of cyanosis since the age of four. There was no significant dyspnea. General development had been quite normal. Marked clubbing of the fingers was present. The heart was only slightly enlarged. There was a harsh systolic murmur and a systolic thrill over the pulmonic area. The blood pressure was 118/88. The electrocardiogram showed right axis deviation. There was the unusual finding of definite diminution in the cyanosis after vigorous exercise although the arterial blood oxygen content was lower after activity. In this case the clinical findings were difficult to interpret. The consensus, however, favored a diagnosis of pulmonary stenosis associated with other lesions.

Cineroentgenographic contrast studies of the patient showed evidence of a septal defect, probably auricular, with a flow of blood from right to left. There was a marked fusiform dilatation of the proximal portion of the pulmonary artery. The pulmonary artery beyond this

dilatation was irregular in outline and there was delay in the passage of blood through the pulmonary artery (Figs. 3*A* and 3*B*).

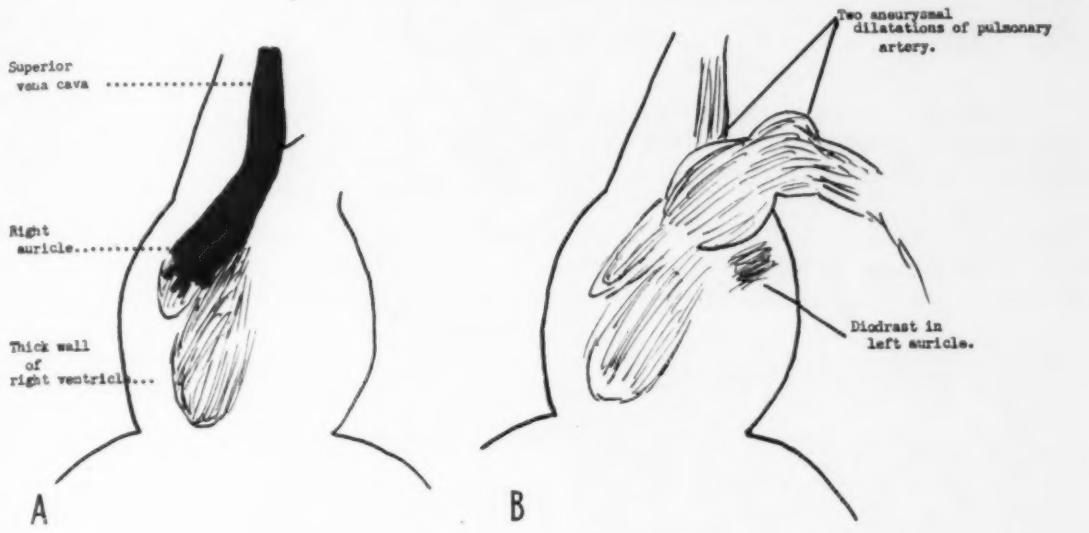

Fig. 3*A*. Case III. Left anterior oblique position. One and one-half seconds after injection. Diodrast has reached the right auricle and right ventricle. The muscular wall of the right ventricle is seen to be hypertrophied.

Fig. 3*B*. Case III. Three seconds after injection. Diodrast has outlined the left pulmonary artery. A large aneurysmal dilatation is seen at the origin of the pulmonary artery; a smaller one is outlined just beyond this. The region of the left auricle is now opaque indicating probable leakage through a patent interauricular septum.

Case IV. The patient was a male, aged fifty-six, who had a typical attack of coronary thrombosis three years previously. At that time he was hospitalized for three months. Later a roentgenogram showed bulging of the cardiac shadow in the region of the left ventricle and a cardiac aneurysm was diagnosed. In spite of this the patient's course continued satisfactory for a period of over three years. Several months ago the patient died of an acute pancreatitis and the autopsy confirmed the diagnosis of cardiac aneurysm.

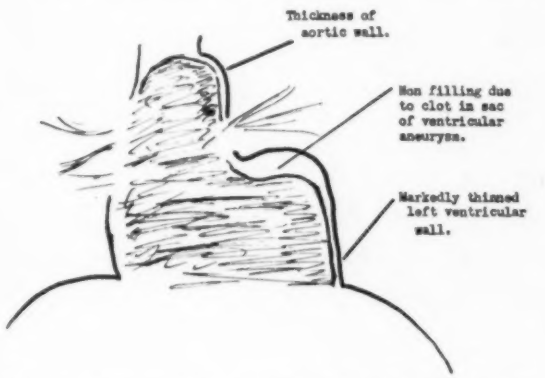
Thickness of aortic wall.
Non filling due to clot in sac of ventricular aneurysm.
Markedly thinned left ventricular wall.

Fig. 4. Case IV. Ten seconds after injection. Nonfilling of aneurysmal sac due to presence of a thick organized thrombus lining it. The muscular wall of the left ventricle is extremely thin. Proved at autopsy.

Preliminary cineroentgenograms demonstrated a bulging of a part of the left cardiac border. This bulging area showed paradoxical motion rather than the normal type of ventricular contraction and confirmed the impression gained from the routine study, of a myocardial infarct which led to development of ventricular aneurysm. Following the injection of diodrast the outline of the left ventricular chamber demonstrated a marked thinning of the muscular wall adjacent to the aneurysm. None of the opaque blood, however, could be detected in the aneurysmal sac, indicating that an organized clot was present. Some time later, at autopsy, the diagnosis of thrombosis obliterating most of the ventricular aneurysm was confirmed (Fig. 4).

In a number of cases in which diodrast was injected, considerable dilatation of the

cardiac chambers and of the great vessels was present. In these the opaque medium rapidly became mixed with such a large amount of blood that no visualization was obtainable.

CONCLUSIONS

In addition to the elucidation of the nature of some congenital cardiac lesions, and the visualization of the cardiac chambers, various abnormalities of the great vessels have been demonstrated. Compression of the large venous trunks may be visualized. The size and course of the pulmonary arteries can be clearly shown. Mediastinal tumors and vascular structures may be differentiated. Cineroentgenography may be able to clarify our knowledge of the living anatomy and physiology of the central portion of the circulatory system. This method can be employed for educational purposes.

We had hoped to be able to demonstrate a "patent ductus arteriosus." While up to the present it has not been possible to visualize such a lesion we have detected certain abnormalities of the greater blood vessels as well as cardiac septal defects which would contraindicate surgical relief in a "patent ductus" detected clinically.*

REFERENCES

1. STEWART, W. H., and GHISELIN, F. H. Cinefluorography. *South. Surgeon*, 1940, *9*, 21–25.
2. ROBB, G. P., and STEINBERG, I. Visualization of the chambers of the heart, the pulmonary circulation, and the great blood vessels in man, AM. J. ROENTGENOL. & RAD. THERAPY, 1939. *41*, 1–17.

* For discussion see page 644.

Vol. 46, No. 5

A NEW TECHNIQUE FOR THE ARTERIOGRAPHIC EXAMINATION OF THE ABDOMINAL AORTA AND ITS BRANCHES*

By DR. P. L. FARIÑAS
HAVANA, CUBA

AFTER the publication of the paper by Dos Santos (1929) describing a technique for the arteriographic study of the abdominal aorta, different communications on the subject have appeared, but his method has not become a routine procedure in general practice due to the difficulties of the blind puncture of the abdominal aorta at the paravertebral region.

In order to avoid the blind puncturing of the aorta, we recommend the arteriographic study of the abdominal aorta and its branches by the puncture and catheterization of the femoral artery at Scarpa's triangle. After local anesthesia the femoral artery is exposed by blunt dissection, mounted in two catguts, and punctured with a trocar through which a catheter is passed, it being introduced to the desired level in the aorta. The patient is placed in position according to the organ to be roentgenographed so that its selective arteriogram may be obtained. A compression at the root of the opposite member is made with a tourniquet, in order to compress the femoral artery and to obtain an ectasis in the abdominal circulation.

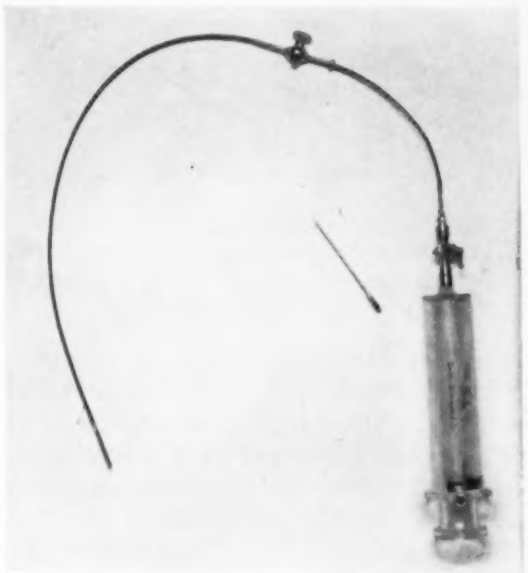

FIG. 1. Necessary instruments: urethral catheter No. 7 or 8 Porges; trocar with stopcock, and a 50 cc. syringe with adaptor and stopcock.

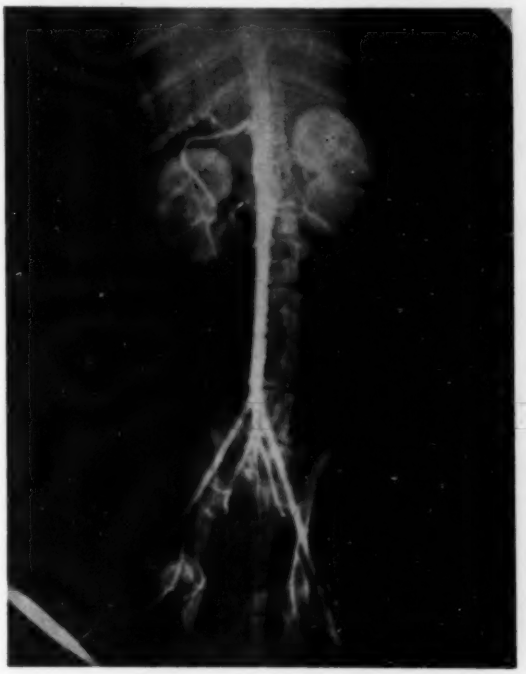

FIG. 2. Aortography by catheterization of the femoral artery. Anteroposterior view showing the abdominal aorta and its branches in a dog.

After the preliminary details are completed, 20 or 30 cc. of a 70 per cent solution of diodrast is injected within two to three seconds through the catheter, and a fast Potter-Bucky film is made. This gives a

* Read at the Forty-first Annual Meeting, American Roentgen Ray Society, Boston, Mass., Oct. 1–4, 1940.

FIG. 3. Aortography by catheterization. Lateral view showing the mesenteric plexus and the lumbar arteries in a dog.

FIG. 4. Aortography by catheterization of the femoral artery. The aorta and its branches are clearly visible. Note the mesenteric plexus.

concentration of 8 to 10 per cent of diodrast in the aorta. The catheter and trocar are then withdrawn and a suture taken in the adventitia of the artery at the site of the puncture and the wound is closed. Using the same injection, a urogram is taken, making plates of the urinary tract after the catheter has been withdrawn.

While trying to use the arterial system in the treatment of cancer of the abdominal

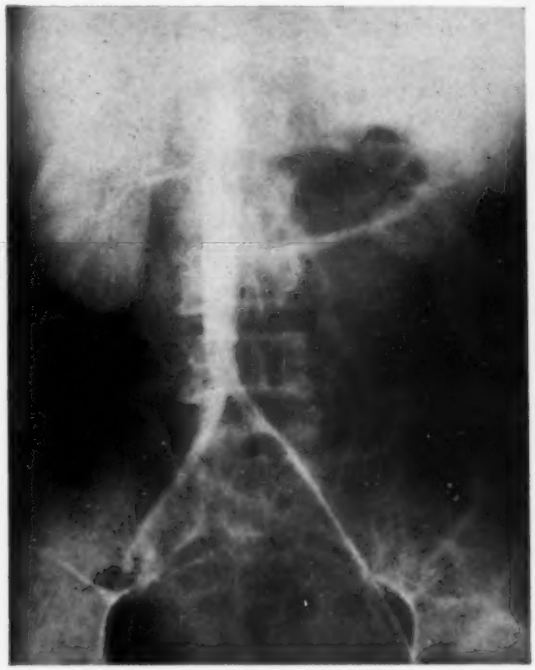

FIG. 5. Selective arteriography of the left kidney. The catheter was placed at the level of the first lumbar vertebra and the patient inclined to the left. The renal arteries are normal.

organs, we started using the puncture of the aorta at the paravertebral region, as recommended by Dos Santos. However, as a result of the difficulties of the blind puncture of the aorta combined with the necessity of having a desired concentration of some substances in the affected organ, the catheterization method under discussion was conceived and employed at the Cancer Institute in Havana.

We started using this method in dogs, and their autopsies did not show any early or late alterations which could be attribut-

ed to the puncture or catheterization of the arteries.

We have had no accidents due to the injection, which is absolutely painless, and patients are able to walk to their beds after the injection. Their autopsies showed no lesions due to the catheterization of the aorta.

The study of the abdominal organs by

Fig. 6. Aortography by catheterization of the aorta. Lateral view in a man.

arteriography gives a great deal of information concerning the anatomical and functional disorders through the modification of the circulation. The alterations in the wall of the aorta and its branches; the study of the renal circulation by its density (secretory function), and by urography (excretory function) with the same injection; the location of abdominal tumors and many obscure problems of the abdominal cavity may be observed by this method.

By employing this technique, a selective study of the circulation of any abdominal

Fig. 7. Abdominal Hodgkin's disease. Note the multiple compressions of the aorta and its branches by enlarged glands.

organ may be made by placing the end of the catheter close to where its artery leaves the aorta, and correct positioning for roent-

Fig. 8. Very large tumor of the liver. Absence of the hepatic artery and the displacement of its branches.

FIG. 9. Large tumor of the uterus. Note the neoplastic vessels and the displacement and compression of the arteries by the tumor.

FIG. 10. Very large tumor of the bladder. Note the displacement of the iliac arteries and the newly formed vessels of the tumor.

genography. We hope that this method will be used wherever indicated, as a substitute for blind puncture of the aorta.

DISCUSSION ON PAPERS BY STEWART, BREIMER AND MAIER, AND FARIÑAS

DR. C. SIDNEY BURWELL, Boston. The two very instructive papers—one by Drs. Stewart Breimer and Maier, and one by Dr. Fariñas—lead me to make the following comments:

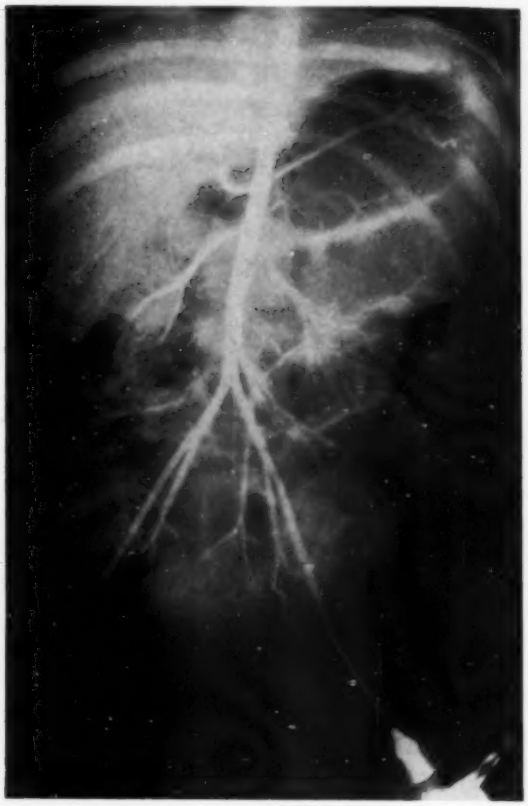

FIG. 11. Large suprarenal tumor on the left side with displacement of the splenic artery. Note the enlargement of the capsular artery on the left side and the new circulation into the tumor.

First, there is no doubt that useful visualization of the heart and great vessels is much aided by the injection of diodrast and the taking of films in rapid succession after such an injection. From such observations come not only useful aid in the diagnosis of individual cases, but also definite additions to our knowledge of the circulation through the heart, great vessels, and lungs. This knowledge may reach the point

where simpler methods will serve for the diagnosis. This is the natural history of many diagnostic methods.

Second, diagnosis in a given patient may be important because it serves as a guide to treatment, because it supplies an answer to the question of prognosis, or because it satisfies the doctor's curiosity. I do not decry this last, which is essential to scientific progress, but the degree of risk which it is proper to assume will vary according to the significance of the information to be obtained. This observation applies to all diagnostic procedures. As the risk increases, the importance of the information to be obtained from the point of view of guiding in the essential treatment of the patient must also increase, and crucial risks may be taken only for crucial decisions. These observations apply to the use of diodrast. Under ordinary circumstances, the risk is small, perhaps minimal, but I cannot persuade myself that the incision of the femoral artery and the introduction of a catheter is a small procedure or one without hazard. Therefore, although such a method may be useful in studying the circulation in experimental animals, its use in patients would appear to me to be justified only by the chance of obtaining information which was decisive in indicating the patient's treatment. Moreover it would be necessary to show that decision could not be reached in a less disturbing way.

Third, there is a point which I would like to make regarding the association of other congenital lesions with patent ductus arteriosus and the bearing of this association on the desirability or undesirability of ligation. It is suggested in the paper of Stewart, Breimer and Maier that certain abnormalities of the great blood vessels and certain septal effects contraindicate surgical relief of patency of the ductus. In the first place, such association of lesions is not common in patients who survive beyond the first months of life, though not unknown. In the second place, if the patent ductus is playing a useful rôle, that is if it is serving as a necessary bypass, the patient will usually and perhaps always be cyanotic. So far I have not heard anyone advance the suggestion of a situation in which a non-cyanotic patient needs a patent ductus. This does not minimize the value of this type of roentgenographic diagnosis of congenital and acquired heart disease. Additional precision in the diagnosis of congenital heart disease is much needed since in this group there are patients who may benefit greatly by appropriate treatment.

Finally, may I express my gratitude for the opportunity of meeting with this Society and discussing these problems of importance to students of the circulation. Cooperative interest and discussion are surely important factors in the advancement and diffusion of knowledge.

Dr. Stewart (closing). So far as the risk is concerned, we have had no serious trouble. Some patients have a little nausea—nearly all a sense of heat which follows almost immediately after the injection—others have an acute urticaria which disappears in a short time. One or two felt a little faint, attributed more to fright than any ill effects of the iodine. We now inject in the recumbent position; this overcomes much of the anxiety.

Our experience, of course, is somewhat limited compared with that of Robb and Steinberg who report no serious ill effects in over 500 injections.

I believe, with Dr. Burwell, that the procedure should be limited to those cases in which a diagnosis cannot be made by any other method. This applies more particularly to congenital heart disease.

Dr. Fariñas (closing). We conceived the method of introducing a catheter through the femoral artery into the aorta as far as the place where the catheter's free end would lie directly in front of the arterial pedicle of an organ affected with a neoplastic process with the purpose of introducing into this organ different highly concentrated substances with which we are experimenting. We now use this method not as a routine procedure but in those instances in which it is not possible to arrive at a definite diagnosis of lesions located in the aorta, its branches or abdominal organs by any other method of examination.

DIFFERENTIAL DIAGNOSIS BY MEANS OF INTRAVENOUS CONTRAST MEDIUM OF TWO CASES SIMULATING ANEURYSM OF THE PULMONARY ARTERY

By SAMUEL ALCOTT THOMPSON, M.D., F.A.C.S.
NEW YORK, NEW YORK

ANEURYSM of the main stem or either branch of the pulmonary artery is found very infrequently. A group of three workers reviewed 37,757 consecutive autopsies without a single instance.[1,2,3]

Up to the present time only 139 cases have been found reported in the literature and of this number, only 27 have been correctly diagnosed before death.[4]

FIG. 1. Case 1. Roentgenogram taken in June, 1939, immediately before the intravenous injection of diodrast. This reveals a large mass in the left hilar region.

Conditions most frequently requiring a differential diagnosis from aneurysm of the pulmonary artery are: aneurysm of the aorta, patent ductus arteriosus, idiopathic dilatation of the pulmonary artery, congenital heart lesions, especially interauricular septal defects, mediastinal tumors and tumors of the lung.

Robb and Steinberg[5] recently demonstrated a safe method for outlining the large vessels of the mediastinum and the cavities of the heart, by the intravenous injection of diodrast, and this procedure has been of particular value in the differential diagnosis of aneurysm of the pulmonary artery.

Since aneurysm of the pulmonary artery is a rare condition and the antemortem

FIG. 2. Case 1. Roentgenogram taken three seconds after the intravenous injection of diodrast. This shows the pulmonary conus and the right and left branches of the pulmonary artery to be normal. Note the difference in contrast between the left pulmonary artery and the mass.

diagnosis has been correct in only 20 per cent, any additional method of diagnosis is especially desirable.

The reason for reporting these 2 cases lies in the fact that in both patients the diagnosis of aneurysm of the pulmonary artery had been made by competent diagnostic groups, and the elimination of this diagnosis was possible only after the use of an intravenous contrast medium.

REPORT OF CASES

Case I. J. de S., male, aged forty-two, Portuguese, was admitted to the Flower and Fifth Avenue Hospital July 27, 1937. He stated that one week previously he had coughed up one quart of blood. He complained of a hard cough which began six weeks previously. He also had a dull pain between the shoulder blades, occasionally becoming sharp and referred to the left side of the chest. Physical examination was essentially normal. The Wassermann reaction was 4 plus. The electrocardiogram was normal. Roentgenography and roentgenoscopy of the chest showed a sharply defined mass in the hilar region on the left side. The mass was about the size of a small orange, and did not pulsate. Bronchoscopic examination revealed the left lower lobe bronchus to be pushed in toward the mediastinum. A diagnosis of carcinoma of the lung was made at this time and an operation for this condition was performed October 19, 1937. At operation a pulsating and expansile mass was found and immediately recognized as an aneurysm. The mass was between the lung and mediastinum anteriorly, and the aorta posteriorly and was completely covered by these structures. Adhesions were particularly dense and no line of cleavage could be established between the mass and the surrounding tissues. Because of the anterior and lateral position of the mass, it was thought to be an aneurysm of the pulmonary artery involving the main stem and left branch, and no further surgical treatment was attempted. His postoperative convalescence was uneventful. The size of the mass gradually increased (Fig. 1) and in June, 1939, the pulmonary artery was outlined with diodrast and the roentgenograms showed the pulmonary artery to be perfectly normal and devoid of any aneurysm (Figs. 2 and 3). Further study now revealed the true diagnosis to be aneurysm of the descending aorta.

Fig. 3. Case I. Same roentgenogram as Figure 2. The left border of the heart, the right and left pulmonary arteries and the mass have been outlined. This eliminates the diagnosis of aneurysm of the pulmonary artery.

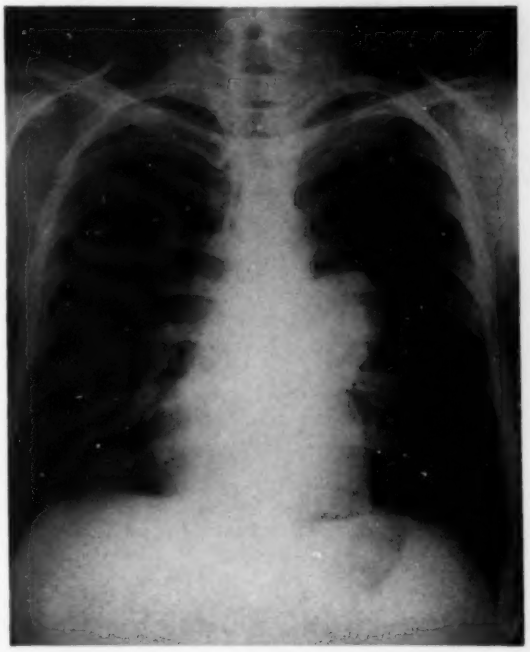

Fig. 4. Case II. Roentgenogram taken in January, 1940, immediately before the intravenous injection of diodrast. Note the mass in the left hilar region.

FIG. 5. Case II. Roentgenogram taken four seconds after the intravenous injection of diodrast. This shows the left and right pulmonary arteries to be normal. Note the difference in contrast between the left pulmonary artery and the mass.

CASE II. An Italian male, aged thirty-seven, was admitted to the Flower and Fifth Avenue Hospital on February 5, 1940, complaining of pain in the left chest anteriorly, shortness of breath and swelling of feet and ankles. About two years before admission he first noticed the shortness of breath which became progressively worse, and six months ago caused him to give up his work as a laundry man. The pain in the anterior part of the left chest was sharp, severe and constant, centering around the region of the third left costal cartilage, For the past few months he had required 3 to 4 grains of morphine a day. Swelling of the feet and ankles was first noticed about six months previously and was most marked when he was up and around during the day. He also had a cough for the past few months, not particularly characteristic, but on three occasions he had coughed up a few flakes of blood. There was a history of weight loss amounting to 8 pounds in the past year.

A few months prior to admission he was examined by a Mid-Western group of clinicians and a diagnosis was made of aneurysm of the pulmonary artery. Immediately prior to his admission he was examined by a competent cardiologist in New York City who referred him to the hospital for wiring of a pulmonary artery aneurysm.

The physical examination revealed very few abnormal findings. There was an area of dullness on percussion with a diameter of about 5 cm. centered over the third left costochondral junction, which was also the region of the greatest pain. Breath sounds were absent in this area and there were no murmurs or thrills. There was osteo-arthropathy of the fingers and toes; electrocardiogram was normal. Bronchoscopic examination showed the left main bronchus compressed and displaced downwards and towards the mediastinum. Roentgen examination revealed a mass in the region of the left pulmonary artery. This mass was about the size of a hen's egg and seemed to pulsate, although this was definitely not expansile (Fig. 4).

Further roentgen study after the intravenous injection of diodrast showed a normal pulmo-

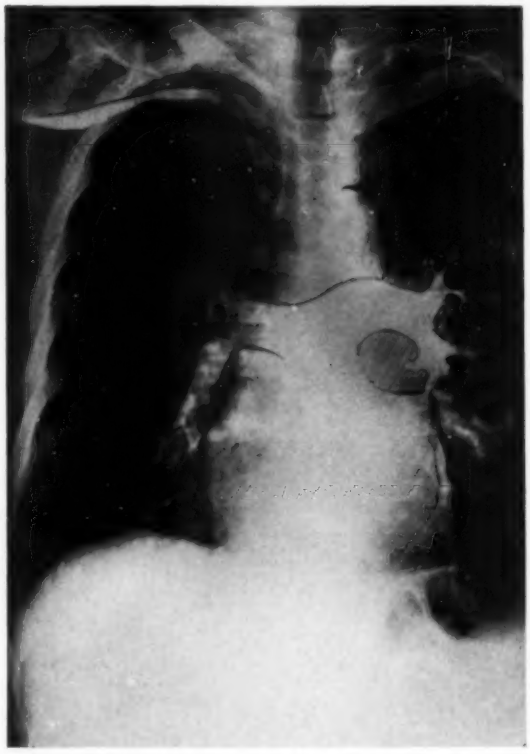

FIG. 6. Case II. Same roentgenogram as Figure 5. The left border of the heart, the left and right pulmonary arteries and the mass have been outlined. This eliminates the diagnosis of aneurysm of the pulmonary artery.

nary artery separate and distinct from the mass (Figs. 5 and 6). A diagnosis of carcinoma of the lung was made and this diagnosis was later confirmed at operation when a squamous cell bronchogenic carcinoma was found.

COMMENT

These two cases illustrate the difficulty encountered in the differential diagnosis of aneurysm of the pulmonary artery, and the additional aid which is now possible by the intravenous use of an opaque solution after the method of Robb and Steinberg.

REFERENCES

1. Jennes, S. W. Diffuse aneurysmal dilatation of pulmonary artery and both of its branches. *Bull. Johns Hopkins Hosp.*, 1936, *59*, 133–142.
2. Scott, R. B. Aneurysm of the pulmonary artery, with report of a case. *Lancet*, 1934, *1*, 567–568.
3. Klotz, Oskar. Concerning Aneurysms. The Third Gordon Bell Memorial Lecture Delivered before the Winnipeg Medical Society, on April 1, 1926. University of Toronto Press, 1926.
4. Boyd, L. J., and McGavack, T. H. Aneurysm of the pulmonary artery; review of the literature and report of two new cases. *Am. Heart J.*, 1939, *18*, 562–578.
5. Robb, G. P., and Steinberg, I. Visualization of chambers of the heart, pulmonary circulation, and great blood vessels in man; practical method. Am. J. Roentgenol. & Rad. Therapy, 1939, *41*, 1–17.

DIVERTICULA OF THE UPPER END OF THE STOMACH

By H. G. REINEKE, M.D.
CINCINNATI, OHIO

"DIVERTICULA of the stomach are rare"—thus begin two of the most comprehensive articles on this subject to be found in the recent literature.[12,22]

Perusal of the available literature reveals a surprising number of reports and discussions covering this abnormality. Martin[12] cites ninety-two pertinent references. In our search of the literature we have found a number of additional articles to which he did not refer. In this paper no attempt will be made to review the literature nor to collect reported cases.

Some difference of opinion exists as to the earliest reported gastric diverticulum. Credit is generally given to Fournier[7] who reported an autopsy in 1774. This report was referred to by Voigtel[25] in such a manner as to cast some doubt on the correct interpretation of Fournier's description. Scattered reports, all of them from autopsies, appeared throughout the nineteenth century. It was not until the first decade of the twentieth century that any real interest developed in the subject and that serious discussions began to appear in the literature. In the second decade more appeared, most of them based on necropsy reports and a very few on roentgen findings. Brown[3] was the first to demonstrate a gastric diverticulum in 1916 before operation. His preoperative diagnosis was gastric ulcer. In the third decade, however, a lively interest is revealed with an increasing number of case reports of diverticula demonstrated roentgenologically. By 1923 Tupper[24] found 38 cases reported. In the same period other excellent papers appeared by Åkerlund,[1] Emery,[6] and others,[8,9,11,17,19,23] including Kalbfleisch,[10] who thoroughly reviewed the literature up to that time, and added a case of his own. Subsequently, Bell and Golden,[2] Moore,[15] Paul,[16] Pendergrass,[18] and Rivers, *et al.*[21] discussed this condition, each contributing not only one or more additional cases to the literature but adding pertinent data as observed by them. The critical analysis of Martin[12] reveals a total of 103 cases which had been reported up to late in 1936.

In considering the subject of diverticula in general for some time, I have been impressed with the necessity of being "diverticulum minded." By this is meant that the condition must always be borne in mind. Had it not been for this attitude several gastric diverticula and many duodenal diverticula might have been overlooked.

There is no standard technique for the demonstration of diverticula of the upper end of the stomach. It appears that a combination of vertical and horizontal positions is necessary for the demonstration of this abnormality. In our cases this combination was responsible for their recognition, whereas if only one or the other had been employed some would not have been found.

Gastric diverticula have been defined by several authors as "circumscribed, more or less bag shaped protrusions from the lumen of the stomach, containing all three layers." Several classifications have been presented, all of them carefully thought out, no doubt, but no two of them being in total agreement. That two basic kinds are found, namely, pulsion and traction, seems to be accepted. Shiflett[22] groups them as congenital, acquired (pulsion and traction), and false diverticula. His classification is based on etiology. Martin[12] simply groups them as pulsion and traction, the former being the congenital group, the latter presumably the acquired type.

In the congenital group we find those gastric diverticula resulting from malformation or interruption in development. This includes gastric muscle hiatus, localized absence of gastric muscle and localized weakness of gastric muscle. In the latter, a sufficient increase in intragastric pressure may distend the weak spot until a pouch or diverticulum is formed. All of the foregoing

can undoubtedly be classified as pulsion diverticula.

In the traction type such pouchings, folds, protrusions and irregularities as are brought about by disease processes in the gastric wall are included. At the same time extrinsic factors which will cause the gastric wall to protrude will produce traction diverticula.

The most common location for the pulsion type of diverticulum is near the cardiac orifice of the stomach. Anatomists agree that the poorest muscular development is in this area.

Diverticula of the fundus of the stomach may be of various shapes and sizes. The orifices are usually small and open into enlarged sacs through pedicles which may vary considerably in length. Occasionally, the diameter of the opening may be larger than the sac, thus giving the diverticulum the appearance of a pouch-like abnormality. We have examined a young physician several times recently who apparently falls into this class but which we are not including in this report because there is some doubt about it. Most diverticula will have a residue after some hours or days which is a valuable aid in diagnosis. When they do not retain barium for more than a moment they are apt to be undiagnosed.

The relatively flabby cardiac end of the stomach may overlie the fundus of the stomach more or less, producing what has been called a cascade stomach. This situation requires a certain amount of experience on the part of the examiner lest it be confused with diverticulum. It can be imagined that this anomaly may have been present in some of the instances where the preoperative diagnosis of diverticulum has not been confirmed at the operating table. On the other hand, one can readily understand why the localization of the opening into a diverticulum may not be found at operation when one considers the possibility of a very small orifice among the coarse folds of mucous membrane in this area. Furthermore, the fundus of the stomach, particularly in the region of the cardiac orifice, is comparatively inaccessible surgically which adds to the surgical difficulties.

Symptoms of diverticula of the gastric fundus are extremely variable. In one of our cases (Case 1) the presence of constant pain in the left epigastrium which radiated upward to the region of the xiphoid, and frequent belching of gas which had a faintly disagreeable odor were so marked that operation had to be resorted to. Mostly, however, the symptoms vary from moderate to mild to no symptoms at all. In some reported cases where other demonstrable conditions have also been present, surgical treatment of these other conditions has relieved all symptoms, even those thought to have been referable to the diverticula.

In considering the symptomatology, an attempt was made to so tabulate all the various types of pain and discomfort with reference to diet, rest, exercise, posture, season, etc., but it was given up as untenable. They are so very variable that no criteria can be enumerated by which one could come to recognize the possible presence of a diverticulum on the basis of history, no matter how painstakingly elicited. Furthermore, no tabulation of physical findings with reference to the location of pain and tenderness has been found to be consistent enough to be of value. The subject finally resolves itself into one of careful clinical and roentgenological study of every patient with gastroenteric complaints.

Symptoms in order of frequency have been pain in the upper abdomen, more often to the left of the midline; belching; pain radiating upward under the sternum and xiphoid; dysphagia. Cheney and Newell[5] reported 4 cases in 1937 in which no characteristic symptoms were elicited and stated that the roentgen examination is the most important examination.

The incidence of gastric diverticula or their relative frequency is very difficult to determine since there is no one adequate series reported by any one author. In the collected cases by Rivers, Stevens and Kirklin[21] 44.2 per cent were found to be in males, 55.8 per cent in females. Diverticula

FIG. 1. Case 1.

have been found in 0.65 per cent of cases by Shiflett,[22] 0.49 per cent by Rigler and Ericksen[20] and in 0.02 per cent by the Mayo Clinic group.[21]

Inflammatory changes are probably not frequent in gastric fundus diverticula because in the reported diverticulectomies no mention is made of them. Carcinoma in these diverticula has been reported but it is so rare that excision of every diverticulum for this possibility hardly seems justified.[5,13,14]

Treatment of diverticula is largely a matter of judgment. Where they are not symptom producing they can be ignored. Otherwise treatment must be designed to relieve whatever symptoms may be present. Smooth diets and antispasmodics have been helpful. Sedatives for patients with neuroses have brought about relief. Postural drainage of a diverticulum is not uniformly successful but should be tried. A procedure not mentioned anywhere in the literature and which has been used in several of our cases is to give the patient small amounts of barium sulfate daily in order to keep the diverticulum filled with it. This is carried out for a period of time up to about three weeks with considerable success.

The following 4 cases are submitted as typical instances of diverticula at the upper end of the stomach near the cardiac orifice.

REPORT OF CASES

CASE 1. Mrs. G. K. G., present age thirty-eight. When first examined roentgenologically in 1926 because of indigestion and pain in the left upper abdomen which was not relieved by diet or medication, she was found to have a diverticulum arising near the cardiac orifice. At that time it had a twenty-four hour residue. It was re-checked repeatedly until 1930 when surgery was recommended for its removal. At operation it was found to arise posteriorly at the level of the cardiac orifice. The pedicle was so inaccessible that the surgeon withdrew without removing it.

In the intervening years I have examined this patient at least once annually. For several years the diverticulum could not be filled with barium by any means whatever. One could usually see a gas bubble in the area where the diverticulum was known to be. On January 2, 1939, another careful examination was done and barium finally found its way into the sac (Fig. 1).

The symptoms at this time have been the same as they were originally and surgery was again being considered as a last resort. Pain was constant and no relief could be obtained. At this point it is interesting to note that when the patient returned for a twenty-four hour study she was cheerful and happier than we had seen her for years because she was free of pain for the first time in months! On examination a barium residue was found in the diverticulum. Since then she has been taking small quantities of barium and is reasonably comfortable.*

CASE 11. C. B., female, single, aged fifty-three. For many years she has been bothered with indefinite discomfort under the xiphoid and lower sternum. A heart lesion, never decompensated, was in some vague way thought by her physician to be responsible for this. Finally a gastroenteric examination was done to make sure that no contributing factor might be present. This revealed a diverticulum near the cardiac orifice (Fig. 2) which filled easily and in which a six hour residue, but not an eighteen hour residue, was found. This patient has been improved by (1) taking liquids before solids and (2) by postural drainage which was studied roentgenoscopically in order to find the most suitable positions for emptying. Whether or not this is actually emptying the sac is not known. Nevertheless, the patient is comfortable.

* Since this paper was submitted the diverticulum has been successfully removed and the patient has had complete relief.

Case III. Mrs. W. J., aged seventy. An extremely neurotic woman with innumerable complaints involving, from time to time, every system in the body. Among other studies, a gastroenteric examination was done. This revealed a diverticulum near the cardiac orifice which filled easily and emptied itself within three hours (Fig. 3). On preliminary plain films the diverticulum is seen to be filled with gas. No symptoms can be traced to the diverticulum.

Case IV. Mrs. W. K., aged sixty-five. This patient fell last autumn (1939) and fractured

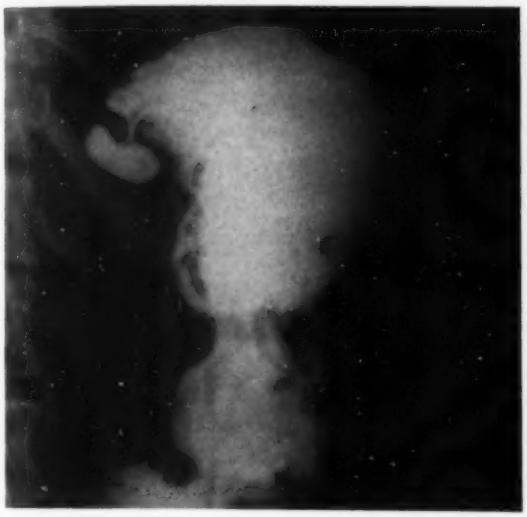

Fig. 2. Case II.

the twelfth dorsal body. She was put to bed for six weeks, on her back most of the time. During this period she developed discomfort under the xiphoid which she had not had before. After she had been up and about for several weeks she came for a gastroenteric study at which time a diverticulum near the cardiac orifice was found which is in every respect identical roentgenologically with that of Case III. Speculation as to the reason for this diverticulum becoming symptom producing at this time is interesting, assuming that it has always been there. Is it possible that because of the position which she was in so much of the time because of her spine injury, some degree of stasis occurred in the sac which caused a low grade diverticulitis? This patient went to a southern resort after this examination and hence we have not been able to study the case further nor do we know whether or not she is improved.

Fig. 3. Case III

SUMMARY

(1) Diverticula of the stomach are rare, occurring in less than 0.05 per cent of cases.

(2) They are most common near the cardiac orifice.

(3) Many are symptomless. When symptoms are present they follow no consistent pattern or formula.

(4) They probably have their origin in some congenital defect.

(5) The roentgen findings are characteristic.

(6) Treatment is rarely surgical. It must be planned to meet the requirements of each case individually.

REFERENCES

1. Åkerlund, Å. Diverticula of the stomach from a roentgenological point of view. *Acta radiol.*, 1923, *2*, 476–485.
2. Bell, J. C., and Golden, R. Diverticula of the stomach. *J. Am. M. Ass.*, 1930, *94*, 534–539.
3. Brown, G. E. Unusual stomach case with roentgenographic findings. *J. Am. M. Ass.*, 1918, *66*, 1918–1919.
4. Case, J. T. Diverticular sarcoma of the stomach. *Am. J. Digest. Dis. & Nutrition*, 1935, *2*, 185–188.
5. Cheney, G., and Newell, R. R. Large diverticula of gastric cardia. *Am. J. Digest. Dis. & Nutrition*, 1937, *3*, 920–923.
6. Emery, E. S., Jr. Diverticula of the stomach. Am. J. Roentgenol. & Rad. Therapy, 1924, *11*, 354–358.
7. Fournier, M. Quoted by Martin, ref. 12.
8. Gray, I. Diverticulum of the stomach. Am. J. Roentgenol. & Rad. Therapy, 1925, *14*, 110–113.
9. Hurst, A. F., and Briggs, P. J. Diverticula of

the stomach; possible source of error in radiological diagnosis of gastric ulcer. *Guy's Hosp. Rep.*, 1924, *74*, 432–439.

10. KALBFLEISCH, W. K. Diverticula of the stomach. AM. J. ROENTGENOL. & RAD. THERAPY, 1928, *20*, 218–223.
11. LAWSON, J. D. Report of a case of gastric diverticulum. *Radiology*, 1926, *6*, 518–520.
12. MARTIN, L. Diverticula of the stomach. *Ann. Int. Med.*, 1936, *10*, 447–465.
13. MAYO, C. H. Diverticula of gastro-intestinal tract, their surgical importance. *J. Am. M. Ass.*, 1912, *59*, 260–264.
14. MELLON, R. R., and others. Incidence of carcinoma in gastro-intestinal diverticulosis. *Surg., Gynec. & Obst.*, 1921, *33*, 177–182.
15. MOORE, A. B. Benign lesions in cardiac portions of esophagus and stomach. *J. Am. M. Ass.*, 1930, *94*, 12–15.
16. PAUL, L. W. Diverticula of fundus of the stomach. *Radiology*, 1935, *24*, 47–52.
17. PEARLSTEIN. F. Diverticulum of cardia of the stomach. *M. J. & Record*, 1926, *124*, 134–136.
18. PENDERGRASS, E. P. Diverticulum of upper end of the stomach. *Surg. Clin. North America*, 1931, *11*, 1493–1496.
19. RAVENEL, L. J. Diverticulum from the anterior surface of the stomach near the cardio-esophageal junction. AM. J. ROENTGENOL. & RAD. THERAPY, 1923, *10*, 904.
20. RIGLER, L. G., and ERICKSEN, L. G. Benign tumors of the stomach. *Radiology*, 1936, *26*, 6–15.
21. RIVERS, A. B., STEVENS, G. A., and KIRKLIN, B. R. Diverticula of the stomach. *Surg., Gynec. & Obst.*, 1935, *60*, 106–113.
22. SHIFLETT, E. L. Diverticula of the stomach. AM. J. ROENTGENOL. & RAD. THERAPY, 1937, *38*, 280–288.
23. SUTHERLAND, C. G. Multiple diverticula, with hemorrhage, in the wall of the stomach. *Radiology*, 1925, *5*, 523–524.
24. TUPPER, E. E. Diverticulum of the stomach. *Wisconsin Med. J.*, 1923, *21*, 442–446.
25. VOIGTEL, F. G. Quoted by Martin, ref. 12.

Vol. 46, No. 5

MEGACOLON

By HORACE W. SOPER, M.D., F.A.C.P.
ST. LOUIS, MISSOURI

THERE is a considerable degree of confusion in the literature in regard to megacolon. It would seem better to reserve the term megacolon or Hirschsprung's disease for the congenital type of neurogenic origin. It was first described by Ammon in 1842, but Hirschsprung's[6] classical account of the disease in 1886 established it as a clinical entity.

Megacolon is characterized by a dilatation of the distal colon with hypertrophy of the muscular coats. Later on in life the peritoneum and mesacolon are thickened, the blood vessels and lymphatic vessels and glands are enlarged, and the mucous membrane becomes thickened and is frequently ulcerated. The majority of the cases appear to originate at the rectosigmoid junction, but at times the dilatation begins at the anal sphincter. It is generally accepted that an embryonic defect occurs, a preponderance of the contractile nerve fibers with a weakness of the relaxing fibers, a condition that Hurst terms achalasia. Rankin believes that the pathogenesis is mixed; that the embryonal defect may exist in the motor mechanism of the bowel, combined with ectasia of the wall of the colon.

The symptoms appear soon after birth: intractable constipation with general abdominal distention. The history, physical examination and roentgen findings establish the diagnosis. The child usually suffers from a secondary anemia and general malnutrition. A large, protuberant abdomen is pathognomonic of the disease. An acquired enlargement of the colon may occur from lesions producing chronic obstruction.

There is another type of colon that is erroneously termed megacolon; viz., the large, redundant, hypotonic colon. This type usually occurs in persons of the asthenic habitus, and a low degree of tonus finally produces extreme redundancy and hypotonicity. Pathologically this type of colon does not exhibit the hypertrophy and thickening of the wall that is found in true megacolon. Bargen, Adson, Lundy and Dixon[1] report cases of functional abdominal distention simulating megacolon.

An acquired form occurs quite frequently. It consists of dilatation of the rectum with strong spasm of the anal sphincter and spastic descending, iliac and pelvic colon. The patient is of sthenic or hypersthenic habitus. I have secured good results in this type by a smooth diet, gradual mechanical dilatations of the anal sphincter and the employment of mineral oil retention enemas.

Surgical Treatment of Megacolon. Many forms of surgical treatment have been employed for megacolon—entero-anastomosis, ileosigmoidostomy, resection, appendicostomy, colostomy and ileostomy. In my series of 50 cases ileosigmoidostomy was performed on 10 patients. Two were successful, the patients securing good colonic function. In the 8 remaining cases reverse peristalisis carried the fecal matter back up to the cecum, and all the patients eventually died of intestinal obstruction. In 4 cases, ileostomy produced good results, the colon showing considerable reduction in size a year or more after the operation. In 3 patients resection was done, 2 patients surviving the operation with good function.

Sympathectomy was first suggested by Wade and Royle[9] in 1927. Judd and Adson[7] reported 2 satisfactory cases in 1928. Watts and Uhle[10] reported 3 cases in which hypotonic bladder was associated with megacolon. Adson states that the mortality rate in surgery of the colon in cases of megacolon was 25 per cent; he reports 22 cases of megacolon having sympathectomy at the Mayo Clinic, with 2 deaths. Ages ranged from five months to nineteen years. The results were excellent when only the descending colon and sigmoid were involved. When the megacolon extended to the left half of the transverse colon the results were not so

Fig. 1. Girl, aged eleven; entire colon enormously dilated just down to the sigmoid flexure. Ileosigmoidostomy was performed with good results.

good. Dixon[3] advises resection as the best type of operation. He employed the two-stage procedure, operated upon 7 patients and excellent results were obtained in 6 cases and there was but one death. He advises that sympathectomy be reserved for the patient during the first three to five years of life. After the second or third decade of life he believes resection is the procedure of choice. He points out that sympathectomy in the male produces impotence and this should always be taken into consideration before the operation is advised. Rankin advises lumbar ganglionectomy or division of the presacral and inferior mesenteric nerves for the congenital type of megacolon. Eiss[4] reports the history of a case of megacolon in a male, aged fifty-nine. The dilatation involved the pelvic, iliac and descending colon. He resected the entire dilated colon with end-to-end anastomosis and had splendid results.

Irrigations and all kinds of cathartics have been employed in the *medical treatment of megacolon*. For the milder cases and the severe forms in which operative interference did not appear to be justified, I have used the following method of palliative treatment. I give 30 to 60 minims of extract cascara sagrada fluid,* t.i.d. before meals to produce steady regular stimulation of the colonic wall. Every third day an enema is given of 2 quarts of 10 per cent solution of sodium sulphate. It must be given slowly through a funnel attached to a No. 28 French soft rubber catheter with the patient in the knee-chest posture. The patient now reclines and a moist compress is held against the anus to hold in the solution as long a time as possible. In a number of cases the results were quite satisfactory, the carmine colored meal being evacuated in from four to five days.

It is true that the cascara eventually produces pigmentation of the mucosa as Bockus, Willard and Bank[2] have demonstrated, but I have never observed any deleterious effects from prolonged employment of the drug.

The sodium sulphate solution is selected

* Parke, and Davis Company.

Fig. 2. This film was secured on same patient one year later showing good function following ileosigmoidostomy.

for the enema because it stimulates the contractile fibers of the colon without being absorbed by the mucosa—in contrast to the sodium chloride and other solutions employed as enemas.

The following case report is of extreme interest:

Patient, female, aged sixteen. Constipation since birth. She was well developed, sthenic type with no undue abdominal prominence. She was athletic, skating and swimming being her favorite exercises. She was 5 feet 6 inches tall, weight 115 pounds.

Barium enema disclosed a very large colon Hirschsprung's type. Rectum was normal in size, the dilatation beginning at the rectosigmoid junction. Proctosigmoidoscopy revealed that the rectum was 6 inches long with normally developed valves, opening at once into the large dilated colon. It required 3 gallons of barium mixture to fill the colon. She made good response to the cascara and sodium sulphate regimen. It is interesting to note that the urine showed a very small indoxyl content. She did not suffer from headaches or any of the usual symptoms of intestinal toxemia. She was kept under treatment for four years, finally the question of marriage and possible pregnancy was raised at the age of twenty years and after consultation the operation of presacral nerve resection and left lumbar ganglionectomy was advised.

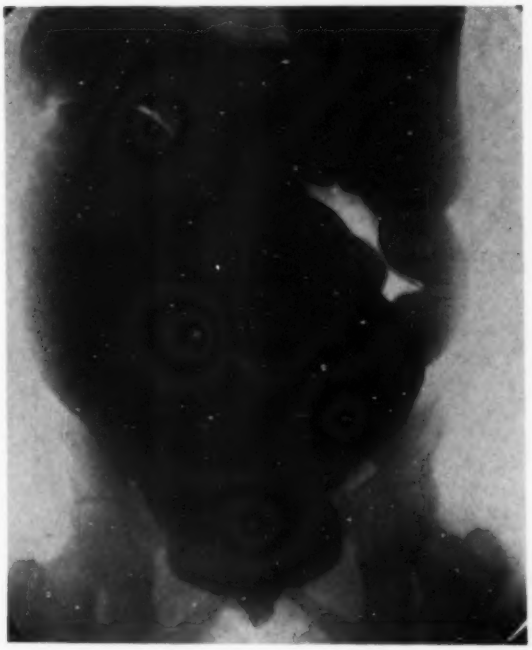

Fig. 3. Large atonic colon often mistaken for true megacolon.

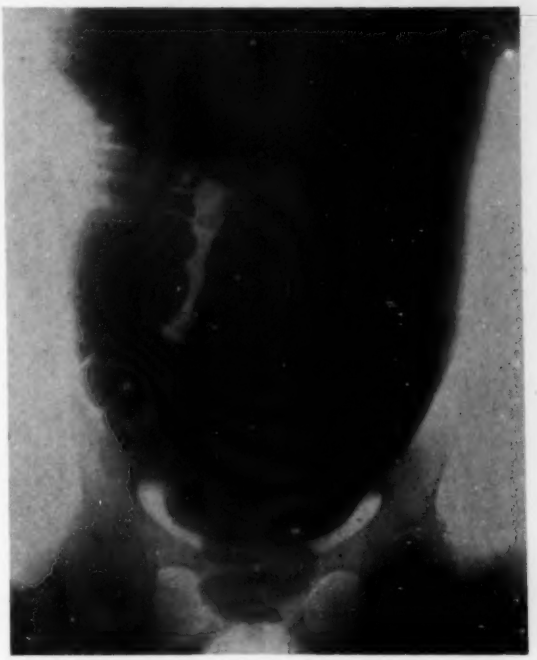

Fig. 4. Large megacolon in girl, aged sixteen. It required 3 gallons of barium mixture to fill it. Death after sympathectomy and sacral ganglionectomy.

This operation was performed by Dr. J. W. Thompson on March 12, 1938. A stormy postoperative condition developed. The abdomen became distended and the large colon filled with liquid feces which was siphoned off, 3,000 to 4,000 cc. daily. She was remarkably dehydrated; the intravenous fluids appeared to empty at once into the dilated colon. She failed rapidly but was kept alive until she finally developed general peritonitis. Death occurred on April 15, 1938. Autopsy report by Dr. W. J. Siebert is as follows:

1. Short small intestine (10 feet) fairly well collapsed.
2. Congenital megacolon beginning at the sigmoid-rectal junction. (No mechanical obstruction, probably neurogenic origin.)
3. Chronic ulcerative ileitis, colitis and proctitis.
4. Visceroptosis, extreme.
5. Diaphragm up to the third interspace, anterior on right; fourth on left.
6. Extreme dehydration and exsanguination especially of the lungs.

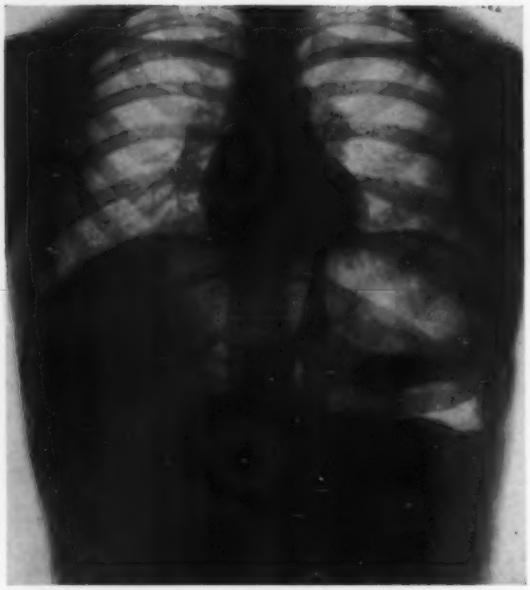

Fig. 5. Same patient, showing high diaphragm and small heart, a remarkable biological adaptation to environment. This patient had no protuberant abdomen.

7. Small heart and hypodevelopment of vascular system.
8. Atherosclerosis of aorta.
9. Presacral sympathectomy (left side) one month.
10. Hypertrophic pyloric stenosis (moderate).
11. Extreme, acute dilatation of the stomach.
12. Localized fibrinous peritonitis, secondary to intestinal obstruction.
13. Extreme dehydration.
14. Old appendectomy.
15. Chronic splenitis, dark, black, firm.

Summary. A case of neurogenic type of congenital severe megacolon (Hirschsprung's disease) that developed an uncontrollable diarrhea after a presacral sympathectomy but marked reduction of size of colon, this permitting a volvulus to occur from the marked lengthened mesentery of the small intestine.

There have been several reports in the literature on the employment of spinal anesthesia as a therapeutic measure in cases of megacolon. The good results appear to be only temporary in character and the cases probably belong to the class which we designate as the large hypotonic colon and not true megacolon.

After a general review of the literature as well as the cases that have come under my personal observation, I would conclude that sympathectomy should be discarded and that resection according to Dixon's method should be employed for all cases of true megacolon, with the possible exception of ileostomy in those patients suffering from a severe form of malnutrition. If this procedure is successful, colectomy may be considered later on. Ileostomy has advantages over colostomy: the feces are devoid of indol and skatol odors, the patient suffers less discomfort, and ultimately the terminal ileum becomes dilated and its rate of motility is decreased. I have records of 12 patients who have maintained a good state of nutrition—from five to twenty years after permanent ileostomy was performed.

REFERENCES

1. Bargen, J. A., Adson, A. W., Lundy, J. S., and Dixon, C. F. Functional abdominal distention simulating megacolon. *Am. J. Digest. Dis. & Nutrition*, 1936, *3*, 17–19.
2. Bockus, H. L., Willard, J. H., and Bank, J. *Tr. Am. Gastro-Enterol. Ass.*, 1933, p. 4.
3. Dixon, C. F. Management of megacolon. *Tr. West. Surg. Ass. (1938)*, 1939, *48*, 433–446.
4. Eiss, S. Megacolon (Hirschsprung's disease). *Am. J. Surg.*, 1936, *34*, 272–285.
5. Hirschsprung. Congenital megacolon (Hirschsprung's or Mya's disease). Sajous Encyclopedia of Medicine, Vol. 11, p. 943.
6. Hurst, Paterson, Rowland and others. *Proc. Roy. Soc. Med.*, 1923–1924 (Sect. Surg., Med. Therapy & Pharm.), *17*, 1.
7. Judd, E. S., and Adson, A. W. Lumbar sympathetic ganglionectomy and ramisectomy for congenital idiopathic dilatation of the colon. *Ann. Surg.*, 1928, *88*, 479–498.
8. Rankin, F. W. Treatment of Hirschsprung's disease. *Kentucky M. J.*, 1935, *33*, 474–478.
9. Wade, R. B., and Royle, N. D. Operative treatment of Hirschsprung's disease. *M. J. Australia*, 1927, *1*, 137–141.
10. Watts, J. W., and Uhle, C. A. W. Significance of hypotonic bladder associated with megacolon. *Urol. & Cutan. Rev.*, 1936, *40*, 244–249.

Vol. 46, No. 5

CASES OF NONSPECIFIC BONE INFECTION WITH UNUSUAL OR OBSCURE FEATURES

By RAYMOND W. LEWIS, M.D.
Roentgenologist, Hospital for Ruptured and Crippled
NEW YORK, NEW YORK

THE following cases of bone infection are presented, largely because they are of interest in themselves, but partly because they emphasize that precise roentgen diagnosis in bone infections is sometimes very difficult.

Case I. F. K. (history No. H31-128), male, aged six, was brought to the hospital with a history of a tumor of the left anterior chest wall of only two weeks' duration. He was admitted for diagnosis and treatment.

Examination showed a large tumor from the second to the fifth ribs. Roentgen examination (Fig 1) showed a large hole in the second rib, with slightly expanded, smooth, rather dense walls. The preoperative clinical diagnosis was tuberculosis. At operation a large abscess coming from the rib was drained. Convalescence was satisfactory. He was discharged two weeks after operation to be followed in the clinic.

Culture showed staphylococcus. Guinea pig injection was negative for tuberculosis. Pathological report: granulation tissue showing areas of abscess formation and elsewhere richly infiltrated with round cells and polymorphonuclears. No evidence of tuberculosis. Diagnosis: acute osteomyelitis of rib.

Comment. From the roentgen findings alone, a positive diagnosis seemed impossible. The bone about the defect in the rib was not eburnated sufficiently to indicate an ordinary bone abscess, or to exclude possibilities such as congenital malformation, cyst, or chondroma. The appearance was consistent with the provisional preoperative clinical diagnosis of tuberculosis. The finally established bacteriological and histological diagnosis of staphylococcus abscess was rather surprising.

Case II. R. C. (history No. C149-816), male, aged seven, was brought to the clinic with the history that four months previously he had hurt his ankle. A few days later there was pain and swelling, with temperature rise. The family physician made an incision over the lateral malleolus, pus was found. The symptoms subsided, and he went about with a limp until two days ago, when the swelling and pain recurred.

Examination at this clinic showed much swelling about the ankle. A roentgenogram (Fig. 2) showed tremendous soft tissue swelling, with extensive destructive changes in the posterior portion of the astragalus. The condition was thought to be tuberculosis. Ten cubic centimeters of yellow fluid was aspirated, plaster was applied, and the patient was instructed to return in six weeks. Smears of the yellow fluid showed pus cells and no organisms, culture showed *Staphylococcus aureus*, guinea pig injection was negative for tuberculosis.

Fig. 1. Case 1. Staphylococcus bone abscess.

The patient showed great improvement upon his return in six weeks (Fig. 3). He was kept in plaster about a year, with steady improvement, at which time the condition seemed healed or entirely quiescent both clinically and by roentgen examination.

Fig. 2. Case II. Staphylococcus abscess of astragalus.

Comment. Two facts in this case are interesting. First, that a condition so like tuberculosis clinically and roentgenologically was found to be a staphylococcus infection. Second, that such a severe staphylococcus infection showed such remarkable improvement in six weeks, and went on to healing, with no other treatment than diagnostic aspiration and plaster immobilization.

Case III. K. B. (history No. H30-900), male, aged twelve, gave a history that about two weeks previously he had mild upper respiratory infection. After about two days there was pain in the left thigh just above the knee. This was dull and aching. One evening, after a feverish day, temperature was 103° F. There was no local redness nor swelling, but there was tenderness 4 or 5 inches above the knee. He stayed in bed twenty-four hours, the symptoms subsided, but he continued to have dull, throbbing, non-radiating pain in the left thigh.

Examination showed increased heat over the lower left femur, with superficial veins slightly dilated. No redness nor swelling. There was tenderness to deep pressure anteriorly and medially, not sharply localized. Rectal temperature 100° F. Sedimentation rate was 12 mm. in

Fig. 3. Case II. Same as Figure 2, six weeks later. Only treatment diagnostic aspiration and immobilization in plaster.

one hour. There was no leukocytosis. Aspiration biopsy was negative for tumor. Cultures were negative. The condition was thought to be low grade staphylococcus infection.

Patient was started on staphylococcus toxin treatment, and was kept in bed for nineteen days, then about the ward for ten days more. Toxin treatment was continued for about one and a half years. Patient had slight intermittent symptoms for about fourteen months, has had no symptoms for the past six months.

Roentgen examination on admission (Fig. 4) showed small cyst-like rarefactions in the lower femoral shaft. Roentgenograms sixteen months later (Fig. 5) showed that the lesions had disappeared. The bone at this time showed slight sclerosis in this region, which was interpreted as indicating healing.

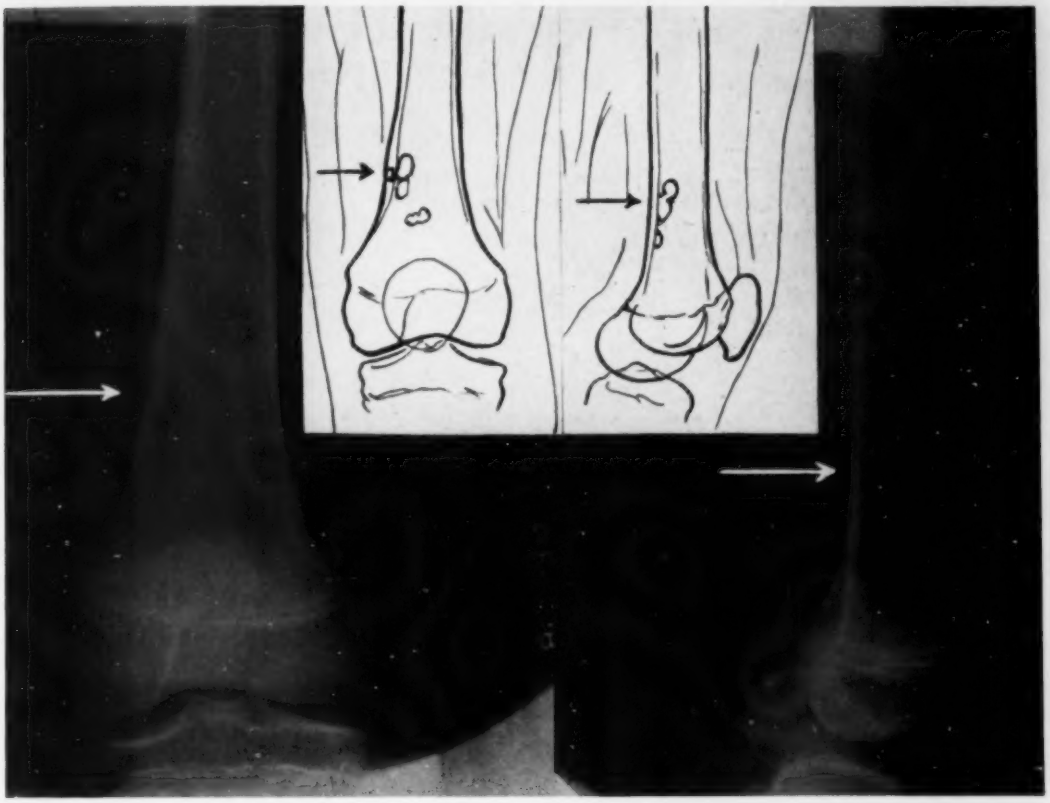

Fig. 4. Case III. Lesion resembling bone cyst or cartilage inclusion. Compare with Figure 6. Probable diagnosis staphylococcus abscesses.

Case IV. R. A. (history No. H34-132), male, aged sixteen, came into the hospital for operation for recurring dislocation of the right patella. Incidental roentgen findings (Fig. 6) were the presence of small cyst-like rarefactions in both lower femoral shafts. The roentgen findings were identical with those in Case III. In the course of operation, the small cyst-like rarefactions in the right lower femur were excised for microscopic study. The pathological report was giant cell variant of osteitis fibrosa cystica.

Comment. Cases III and IV are of interest for two reasons: (1) Reasonably certain diagnoses were obtained in a frequently encountered but seldom diagnosed bone condition. When these small cyst-like rarefactions are encountered, the condition is usually guessed to be growth defect of bone, cartilage inclusion, or cyst. Since operation or biopsy is usually not indicated, the diagnosis usually remains unestablished. (2) In two roentgenologically identical conditions, two totally different pathological processes were found. In

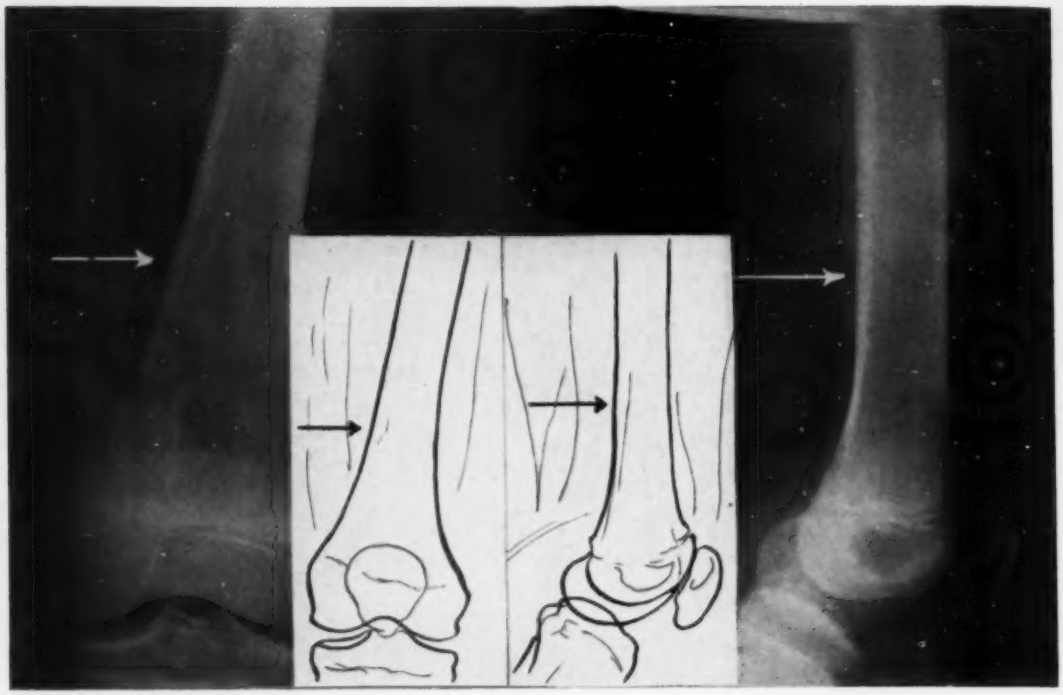

Fig. 5. Case III. Same as Figure 4, sixteen months later, after staphylococcus toxin treatment. Disappearance of lesions.

Case III a final diagnosis of staphylococcus infection of bone seems warranted; in Case IV a histological diagnosis of giant cell variant of bone cyst was established.

Case V. L. S. (history No. H14-883), male, aged seven, was seen in the clinic on January 24, 1934, with a history of inability to walk on the left heel for the past week because of pain. Examination showed marked tenderness about the calcaneus, some heat. A roentgenogram at that time was negative. The symptoms persisted, and the boy was admitted to the hospital on February 6, 1934. A roentgenogram on February 7 (Fig. 7) showed a large area of destruction in the calcaneus, with what appeared to be a small central sequestrum. Incision and drainage March 1, 1934. Culture showed gram-positive staphylococcus. Pathological report: chronic osteomyelitis. Patient was seen in the end-result clinic on January 29, 1935. The wound was completely healed, there was a normal range of motion.

Case VI. N. M. (clinic No. C115-951), male, aged thirty-two, was followed in the clinic from April 28, 1936, to July 21, 1936, with the complaint of a discharging sinus on the lateral aspect of the right os calcis. His previous history stated that he had been admitted to Roosevelt Hospital on May 15, 1935, with a history of a year's pain, redness, swelling, and tenderness over the os calcis. Two days after admission to that hospital, the bone cavity was opened, curetted, and packed with iodoform gauze. The wound did not close. The pathological report was osteomyelitis due to tuberculosis.

A roentgenogram taken on May 1, 1936 (Fig. 8) showed the destruction in the calcaneus. Patient was treated conservatively in this clinic, the sinus did not close, the patient disappeared.

Comment. Cases V and VI presented identical roentgen findings, and were indistinguishable roentgenologically. Case V was staphylococcus bone abscess, Case VI tuberculous bone abscess.

Case VII. S. A. (history No. H30-682), male, aged twenty-five, gave a history of insidious onset of intermittent limitation of motion in the elbow, ten years' duration, without known injury. Symptoms usually lasted only a few days. About four months ago, the symptoms became more severe, were not relieved by the

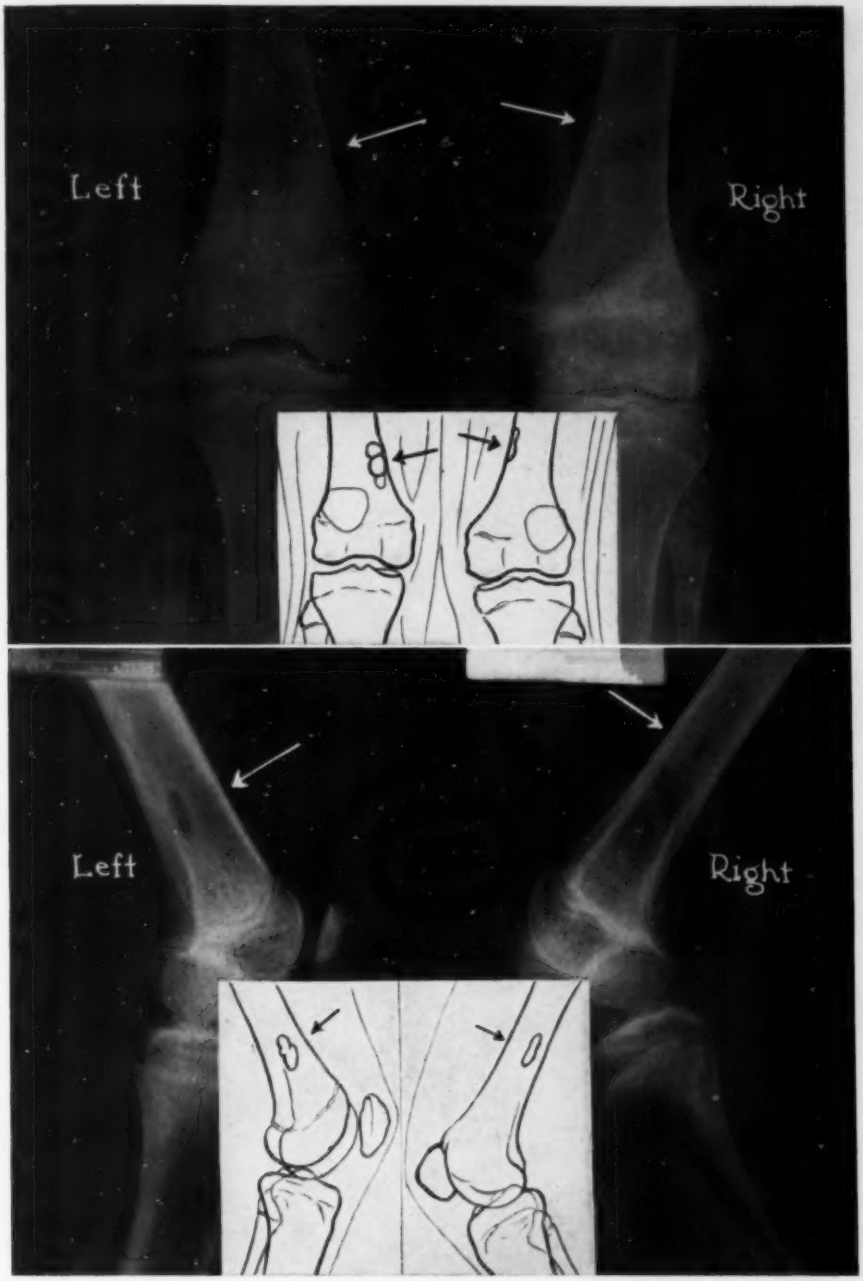

Fig. 6. Case iv. Lesions identical with Figure 4. Histological diagnosis giant cell variant of osteitis fibrosa cystica.

usual hot applications. Aspiration by the local doctor withdrew about 40 cc. of seropurulent material. The joint has since remained painful with limited motion. Examination showed swelling posteriorly between the olecranon process and the lateral condyle, and a little limitation of motion. No tenderness, no pain on motion. Roentgen examination (Fig. 9) showed a sharply defined, rounded rarefaction above the capitellum and lateral to the olecranon fossa, with a good deal of density in the surrounding bone.

On January 20, 1939, exploration and biopsy. A bone cavity filled with yellow gray granula-

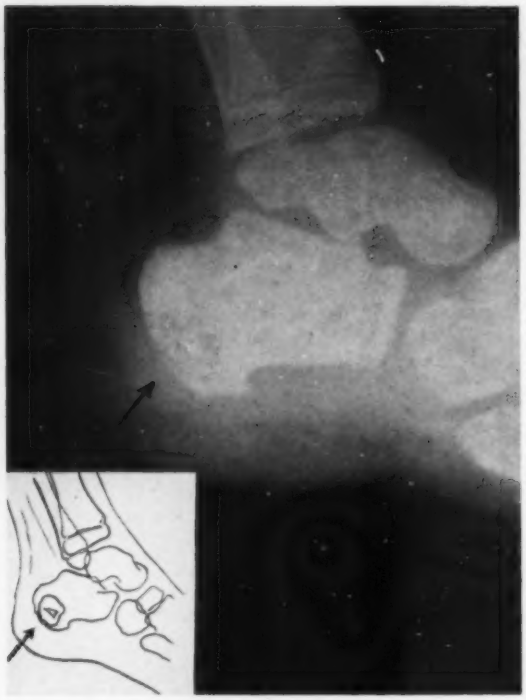

Fig. 7. Case v. Staphylococcus abscess of calcaneus. Compare with Figure 8.

tion tissue was found. Culture was sterile. The wound healed promptly. Pathological report: connective tissue, sclerotic blood vessels, few spicules of dead bone, areas of round cell infiltration. The appearance suggests an old inflammatory condition of the nature of Brodie's abscess.

Subsequently the patient had a number of recurrences of pain and swelling, sometimes with elbow synovitis. Three aspirations and guinea pig inoculations were negative for tuberculosis.

Case viii. M. R. (hospital No. H26-930), male, aged thirty-eight, was admitted June 23, 1937. Seven or eight years ago, without history of injury or infection, he had a swollen left knee. This was aspirated three times by a local doctor. Since then he has had occasional swelling of the knee, with symptoms more marked recently. Examination showed slight swelling of the left knee joint, no redness, heat, or tenderness. A roentgenogram (Fig. 10) showed a quite sharply defined, rounded rarefaction just above the medial tuberosity, situated posteriorly. There was no reaction in the surrounding bone.

Operation June 26, 1937. A Brodie's abscess

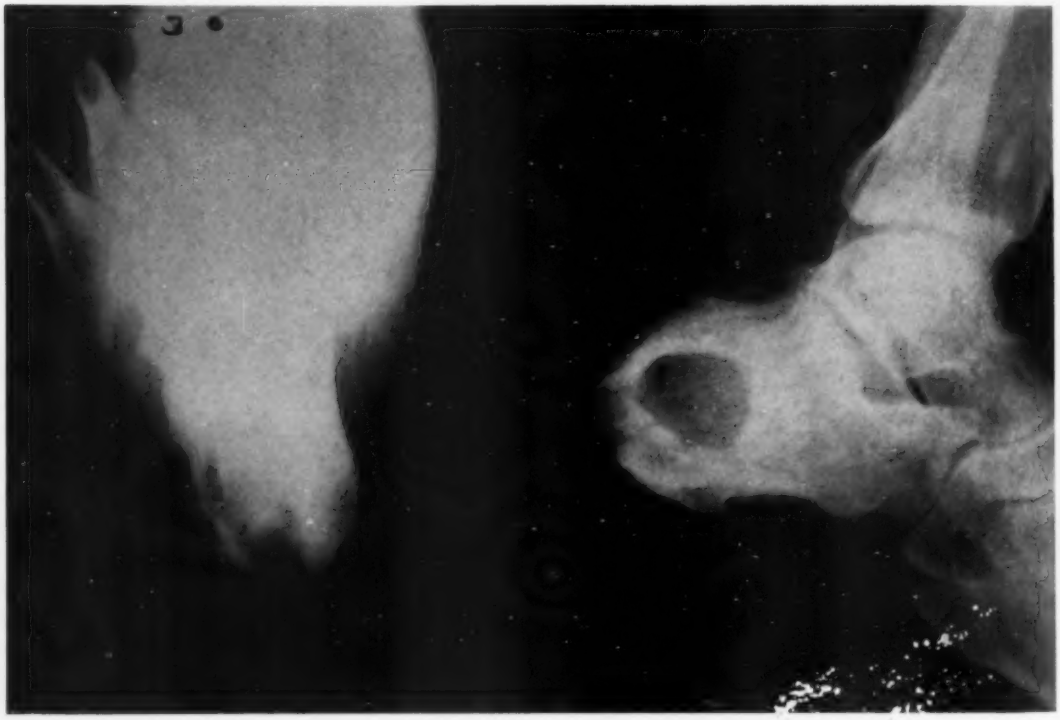

Fig. 8. Case vi. Tuberculous abscess of calcaneus. Compare with Figure 7.

Fig. 9. Case vii. Probably non-tuberculous bone abscess. Compare with Figures 10 and 11.

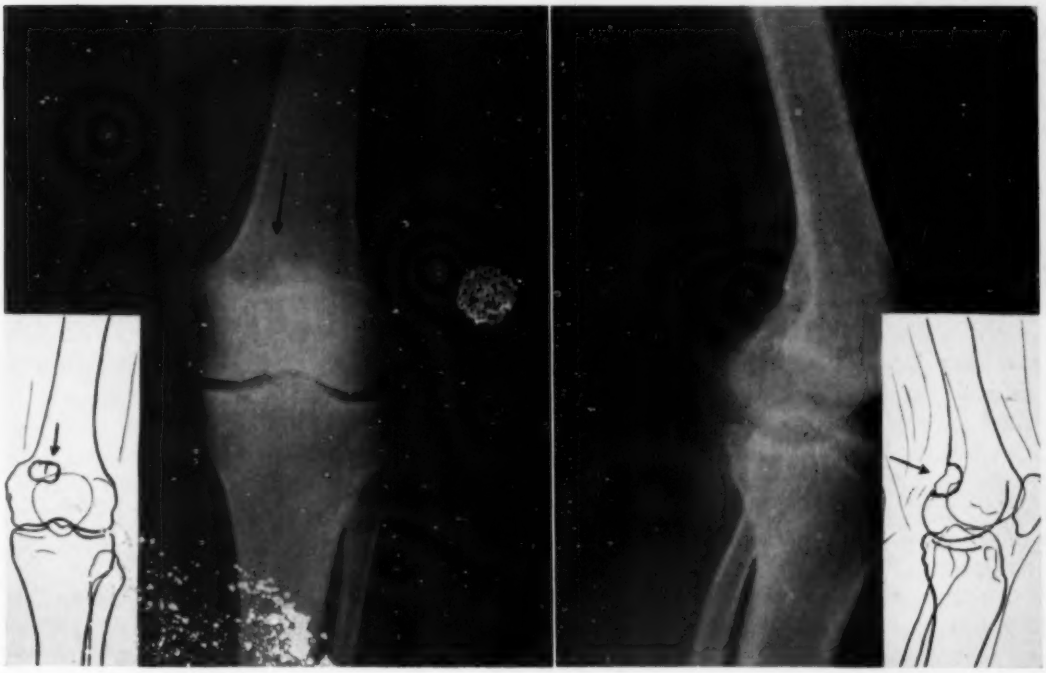

Fig. 10. Case viii. Staphylococcus bone abscess. Compare with Figures 9 and 11.

Fig. 11. Case ix. Tuberculous bone abscess. Compare with Figures 9 and 10.

was curetted out. The wound closed primarily, there was uneventful recovery. Culture and smear showed staphylococcus. Patient was seen December 12, 1938; there had been no recurrence of symptoms.

Case ix. J. L. (history No. H24-715), male, aged forty-five, was seen in the clinic December 2, 1936. About thirteen years ago he noticed a small swelling on the outer side of the calf, just below the knee joint. There was slow increase in size. Pain and discomfort have been present the past two weeks. He went to Memorial Hospital where roentgenograms were taken (Fig. 11) showing a large area of bone destruction in the lateral condyle of the tibia, with a very large overlying soft tissue mass. Aspiration was done, 20 cc. of thick fluid was obtained in which tubercle bacilli were found.

Examination in this clinic showed a large fluctuant swelling covering the lateral aspect of the left leg from knee joint line to the junction of the upper and middle thirds of the leg.

On December 31, 1936, there was incision and drainage with primary closure of the wound. Smear showed tubercle bacilli. Pathological report: probably tuberculosis.

The abscess re-formed. Incision and curettage on February 27, 1937, with primary closure. Guinea pig inoculation was positive for tuberculosis. Patient was seen February 28, 1938, at which time he was clinically and roentgenologically well.

Comment on Cases VII, VIII and IX. Cases vii and viii presented interesting problems in diagnosis. In Case vii there was too much reaction in the surrounding bone to suggest anatomical variation. Likely diagnoses were tuberculous or non-tuberculous abscess. The rather limited reaction in the surrounding bone favored the former diagnosis; the history of onset following a boil favored the latter. In Case viii we could not determine whether the condition was infection, giant cell tumor, or neoplasm.

A reasonably certain final diagnosis in Cases vii and viii was non-tuberculous abscess. Case ix, which presented many similar roentgen findings, was a tuberculous abscess.

THE ROENTGENOLOGIC ASPECTS OF SUBUNGUAL GLOMUS TUMOR

By EDWIN L. RYPINS, M.D.
BLOOMINGTON, ILLINOIS

AMONG the various terms applied to glomus tumors have been angioneuroma, Popoff tumors, arterial angioneuroma of Masson (Humphrey and Brainard[5]), angiosarcoma, subcutaneous painful tubercle, perithelioma, glomangioma, angiome and neuromyo-arterial glomus (Larson and Bennett[6]). Glomus tumor is probably the term of choice since it is the one generally accepted by various writers.

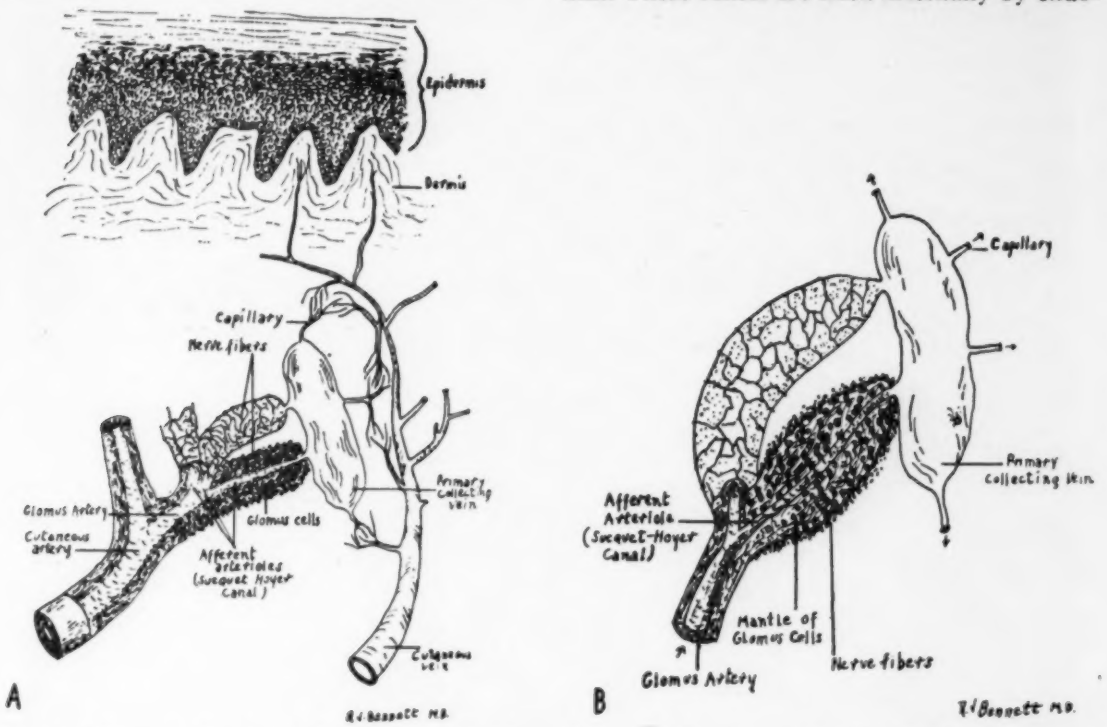

FIG. 1. Schematic drawings of glomus. *A*, showing relation of glomus to skin, and *B*, magnification of central part of *A*. This is the portion of the glomus which undergoes the hyperplastic changes observed in the glomus tumors. (Reproduction through courtesy of Larson and Bennett and *Western Journal of Surgery and Obstetrics*.)

Briefly the neuromyo-arterial glomus is a normal vascular anastomosis which is distinctive in that it is arteriovenous with no intervening capillaries and that it has a peculiar architecture which includes smooth muscle and nerve fibers. (See Fig. 1.) The glomus is distributed widely over the surface of the body but is most abundant at the tips of the extremities under the nails. The normal cutaneous glomus is found in the reticular layer of the cutis and consists of an afferent artery and a collecting vein. The afferent artery divides into from 2 to 4 branches which have been named the Sucquet-Hoyer canals. These canals are lined internally by endothelium which is surrounded by a layer of smooth muscle. Among the muscle fibers are large cells with a round nucleus and clear cytoplasm which have been variously termed epitheloid cells, endothelial cells, perithelial cells, modified muscle cells and glomus cells. The exact origin of the cells has not been determined but the majority of opinions seem to favor a myogenic origin. The glomus cells are innervated by a rich network of nonmyelinated nerve fibers. The Sucquet-Hoyer canals drain directly into collecting veins (Larson and Bennett[6]).

The function of the cutaneous glomus is concerned with heat regulating which is done by alternating the flow or volume of blood in the capillary bed. This fact has been shown experimentally (Radasch[11]). Most of these neuromyo-arterial bodies are found in the skin or subcutaneous tissue of the hands and feet and thus the majority of glomus tumors are found in these parts (Humphrey and Brainard,[5] Lewis and Geschickter[8]). Thermal, tactile and chemical stimulation will produce dilatation of these arteriovenous anastomoses (Larson and Bennett[6]). This system is absent in the fetus and development of this system takes place in the first months of postnatal life (Radasch[11]).

Organic overgrowths of the normal glomus may produce cutaneous tumors. These tumors are always small, the largest reported being 3 cm. in diameter (Larson and Bennett). One-third of the tumors have been subungual and nearly one-half have occurred in the digits (Oughterson and Tennant[10]). The tumors are usually purple-blue or bluish- to violet-red[4,3] in color and lie within the cutis. Bailey[2] reports that about 50 per cent of tumors occurred in the

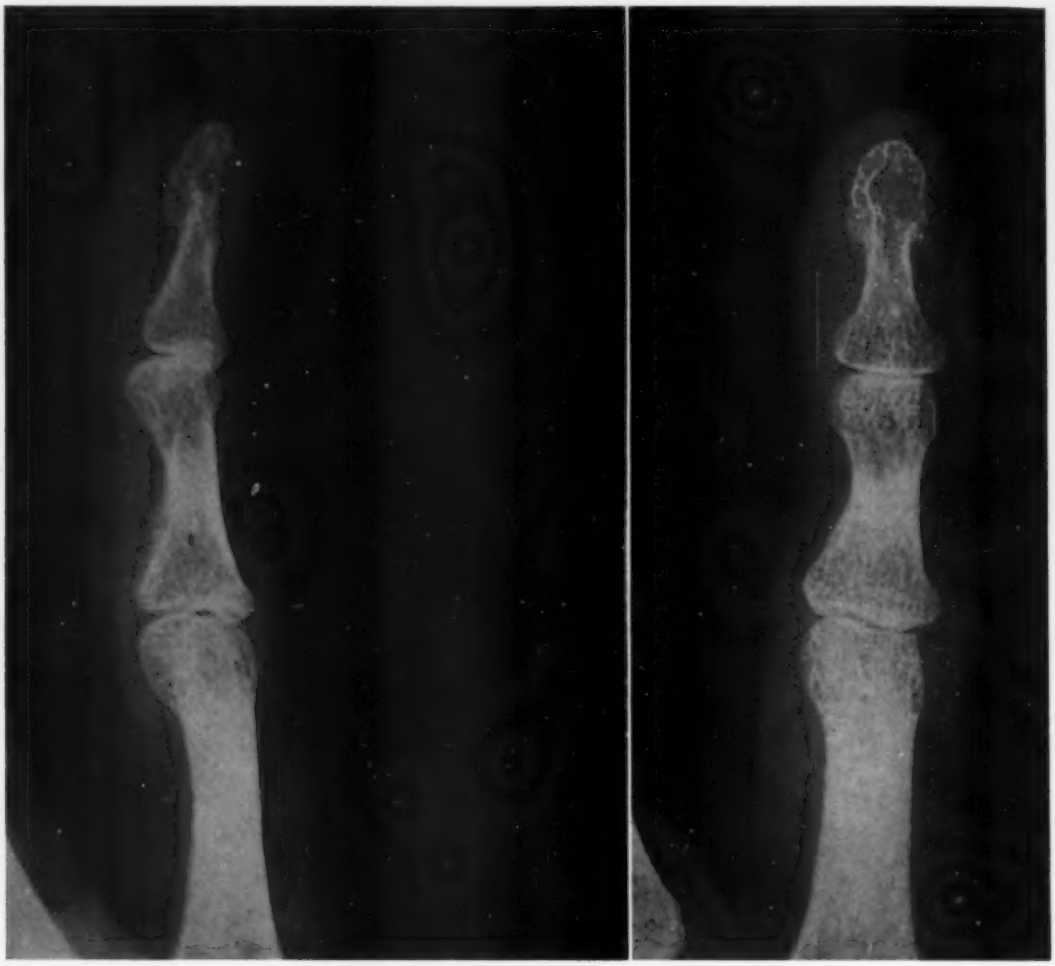

Fig. 2. Roentgenograms of the right fifth finger in April, 1939, before the glomus tumor was removed. Note the fairly clean-cut destruction of the cortex of the distal end.

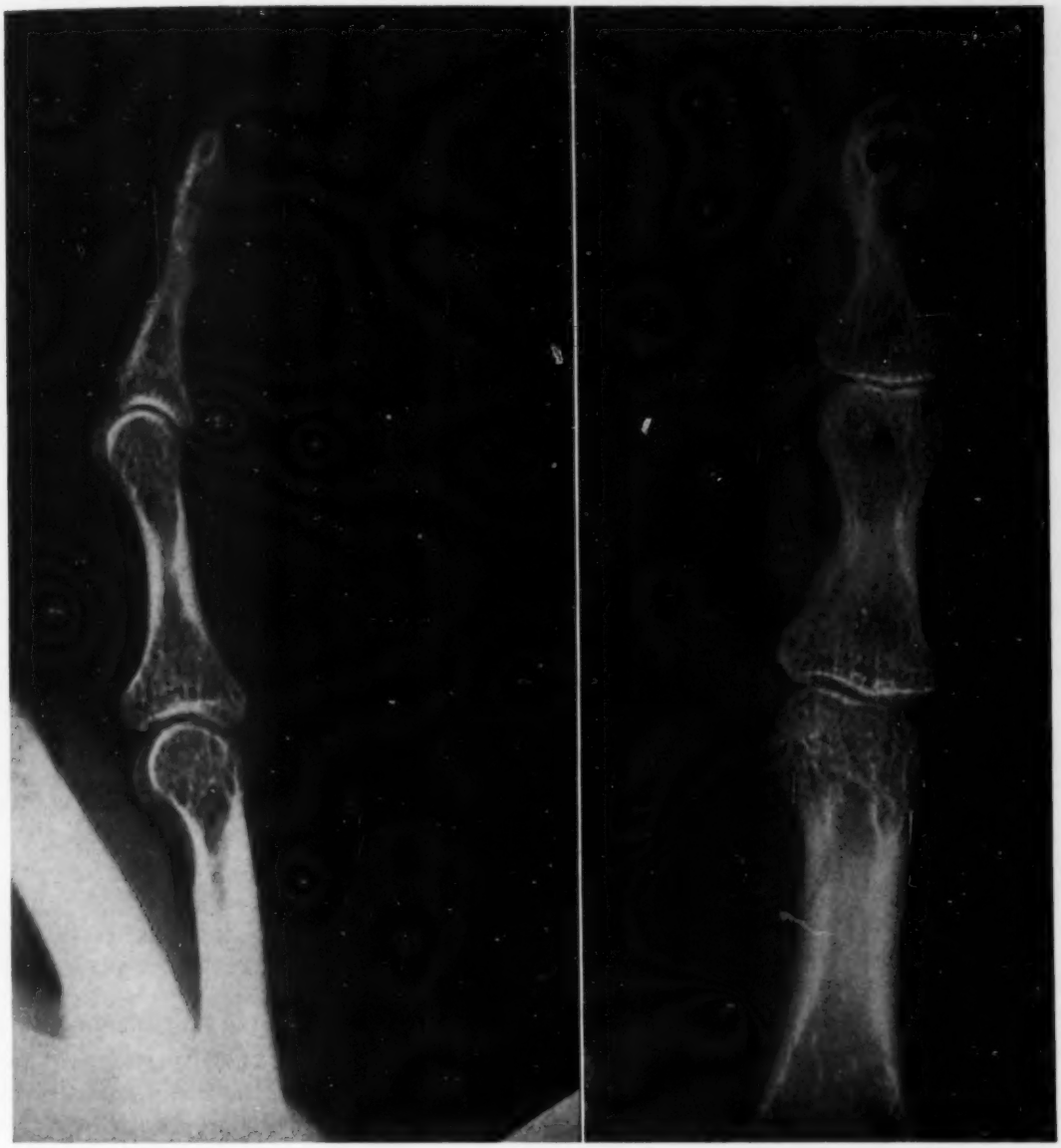

Fig. 3. Roentgenograms of the fifth finger of right hand September, 1940. Note the absence of a portion of the medial border of the terminal phalanx which was removed previously and no pus discovered. The destruction of the terminal portion of the phalanx is less apparent at this examination indicating healing since the tumor was removed.

subungual region. Various other sites have been reported such as the knee, elbow or trunk. Tumors are usually single although Adair[1] and Bergstrand and Touraine[4] report multiple ones. The etiology of trauma seems to be questionable. Mason and Weil[9] noted trauma in only 36 per cent of the cases. Theis[14] states that a history of injury is given in 50 per cent of cases.

Histologically the glomus tumor is characterized by dilatation of the lumen of the Sucquet-Hoyer canal and hyperplasia of the glomus cells. There is dilatation of the arterial lumina which accounts for the he-

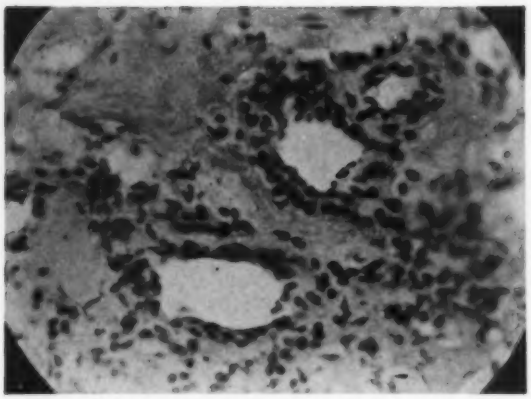

Fig. 4. High power magnification of section of glomus tumor.

mangiomatous appearance of the tumor. Nerve fibers both myelinated and non-myelinated are found between and terminating in the glomus cells (Larson and Bennett). The glomus cells are the ones upon which the diagnosis rests. These large cuboidal cells have a circular nucleus with a well-stained reticular chromatin and a well-marked limiting membrane as shown by Masson's trichrome stain. There seems no doubt that this is the same type of cell seen in the wall of the Sucquet-Hoyer canal of the normal arteriovenous anastomosis of the skin (Lendrum and Mackey[7]). The tumors may best be classified as hamartomas rather than as true neoplasms since they originate in and more or less reproduce a normal structure of the body (Larson and Bennett).

REPORT OF CASE

Female, white, aged twenty-three, was referred for roentgen examination of the fifth finger of the right hand on April 24, 1939 (Fig. 2). In April, 1938, the patient began having pain in the end of the little finger of the right hand which interfered with her occupation of stenographer. Pain would keep her awake. She obtained considerable relief by having the nail scraped. At the time of the roentgen examination the end of the fifth finger was definitely swollen and tender but no color changes in either the finger or nail were noted. In June 1939, an incision was made along the medial border of the tip of the right little finger. A portion of the bone was curetted but no pus was discovered. Patient had complete relief of pain until April, 1940. At this time a reddish spot, pinhead in size, was noted just under the middle of the nail. The distal half of the nail was removed and a small tumor readily shelled out from underneath the nail bed. On September 6, 1940, the nail had practically grown out and patient was perfectly free of all symptoms (Fig. 3). On pathological examination by Dr. B. Markowitz a diagnosis of glomus tumor was made (Fig. 4).

Addendum. The patient returned on June 20, 1941, with the statement that approximately six months ago, or roughly six months following the removal of the glomus tumor, she had a recurrence of symptoms. The nail was purple in color and the patient was extremely tender to the slightest pressure over the edge of the nail but not over the sides of the finger. No definite white points were seen over the nail. Roentgen examination on June 20, 1941, showed a very small, clean cut area of destruction just medial to the area seen on April 24, 1939 (see Fig. 2). This new area of destruction was diagnosed as another glomus tumor. To date (October 10, 1941) the patient has refused further surgical procedures although she admits that the symptoms are definitely more severe than in June, 1941.

COMMENT

The characteristic clinical finding in a glomus tumor is the extreme pain of the extremity which may be present before the tumor is visible (Humphrey and Brainard). Lewis and Geschickter record one case in which the tumor was of such minute size that it was not located until the third operative attempt. Pain is described as burning, piercing, exquisite, agonizing and bursting.[1,5,7] Invariably the tumor is sensitive to pressure and in some cases it is associated with neurologic or vascular changes such as hyperesthesia and increase in temperature of the skin. Examination reveals a pea-sized tender tumor, which, when subungual, has almost always a peculiar bluish tinge showing through the translucent nail (Raisman and Mayer[12]). For an excellent photograph of this tumor the reader is referred to the article by Raisman and Mayer[12]. They state that the roentgenogram may show a minute crater-like de-

pression of the dorsal cortex of the terminal phalanx. Stout[13] has noted a "hollowing out" of the bone in the roentgenograms of 3 cases. Oughterson and Tennant suggest that the tumor because of its pulsatile character when in contact with bone frequently erodes through the cortex like an aneurysm. Mason and Weil[9] state that the roentgenogram in the case of glomal tumor will frequently reveal a small, shallow depression in the distal phalanx and Becker[3] states that "occasionally erosion of the terminal phalanx may be seen on Roentgen examination."

In the differential diagnosis lesions such as subungual fibroma and papilloma, ganglion and melanotic whitlow must be ruled out by history or biopsy. According to Raisman and Mayer[12] the subungual melanoblastoma may cause difficulty in differential diagnosis. If the glomal tumor is not situated beneath the nail it must be differentiated from warts, nevi, lipomas, fibromas and small sebaceous cysts. Subungual exostosis should be bony hard and seen on the roentgenograms as such rather than as a destruction of the cortex (Fig. 2). They do not cause pain or bluish discoloration and are much more common in children. Subungual corn may occur at any age but does not cause pain or bluish discoloration. This is also true of subungual papilloma. Subungual fibroma is apt to distort the fingers and toes as well as the nails. There is no pain or discoloration. Epithelial bone cysts of the terminal phalanx do not cause this clean-cut destruction of the cortex. Subungual enchondromata are multiple. The subungual angiokeratoma causes a red spot under the nail and, according to Raisman and Mayer, is not diagnosed except by biopsy. Boeck's sarcoid causes damage to the growth of the nail and is an ovoid, hard, paronychia-like lump with a blue-red color. Melanoblastoma is the most common malignant subungual tumor, which apparently has a slow growth. After a long period of time ulceration of the subungual tumor occurs with either spontaneous or operative removal of the nail. The wound does not heal and pigmented dots are noted. Usually by the time a definite diagnosis is made metastases have occurred. Commonly the bluish-black spot seen under the nail resembles somewhat that seen with the glomus tumor but microscopically there is not the least resemblance. Raisman and Mayer neglect to state whether there are any bone changes in melanoblastoma but one would gather that there are not. The pyogenic infections of the terminal phalanx involve the periphery and with involvement of the cortex one would expect a more ragged lesion to result rather than the clean-cut one noted in Figure 2.

Simple excision is all the treatment necessary. Glomus tumors are benign and do not recur after removal (Larson and Bennett, Raisman and Mayer) but it is possible for the tumor to reappear long after operation (Stout).

CONCLUSIONS

(1) Quoting Adair,[1] "There is no other lesion in the entire realm of oncology which gives the tell-tale clinical features of the glomus tumor."

(2) When the roentgenologist sees a clean-cut destruction of the cortex of a terminal phalanx a glomus tumor should be suggested as the most likely possibility for the cause of the destruction.

(3) A history of excruciating pain of the terminal phalanx, with or without a discoloration or tumor underneath the nail, and a clean-cut destruction of the cortex of a terminal phalanx is diagnostic of a glomus tumor.

(4) A case of subungual glomus tumor showing definite bony change is reported.

I wish to thank Dr. George W. Stephenson for supplying the clinical data for this case.

REFERENCES

1. Adair, F. E. Glomus tumor. *Am. J. Surg.*, 1934, *25*, 1–6.
2. Bailey. Quoted by Humphrey and Brainard, ref. 5.
3. Becker, F. T. Tumors of neuromyo-arterial glomus. *Minnesota Med.*, 1940, *23*, 78–82.
4. Bergstrand and Touraine. Quoted by Humphrey and Brainard, ref. 5.

5. Humphrey, A. A., and Brainard, C. W. Subungual glomus tumors. *Internat. Surg. Digest*, 1937, *24*, 259–264.
6. Larson, C. P., and Bennett, R. G. Glomus tumor. *West. J. Surg.*, 1938, *46*, 600–602.
7. Lendrum, A. C., and Mackey, W. A. Glomangioma. *Brit. M. J.*, 1939, *2*, 676–681.
8. Lewis, D., and Geschickter, C. F. Glomus tumors (arterial angioneuromyoma of Masson). *J. Am. M. Ass.*, 1935, *105*, 775–778.
9. Mason, M. L., and Weil, A. Tumor of subcutaneous glomus. *Surg., Gynec. & Obst.*, 1934, *58*, 807–816.
10. Oughterson, A. W., and Tennant, R. Angiomatous tumors of hands and feet. *Surgery*, 1939, *5*, 73–100.
11. Radasch, H. E. Glomal tumors. *Arch. Path.*, 1937, *23*, 615–633.
12. Raisman, V., and Mayer, L. Tumor of neuromyo-arterial glomus. *Arch. Surg.*, 1935, *30*, 911–929.
13. Stout, A. P. Tumors of neuromyo-arterial glomus. *Am. J. Cancer*, 1935, *24*, 255–272.
14. Theis, F. V. Subungual neuromyo-arterial glomus tumor of the toe. *Arch. Surg.*, 1937, *34*, 1–11.

Vol. 46, No. 5

IRRADIATION OF THE PITUITARY GLAND IN POSTERIOR LOBE HYPERFUNCTION CONTROLLED BY BIOLOGIC TESTS*

By EUGENE P. PENDERGRASS, PHILIP J. HODES, *and* JOHN Q. GRIFFITH, JR.†
PHILADELPHIA, PENNSYLVANIA

THERE is now good experimental and clinical evidence that the posterior lobe of the pituitary is an important gland of internal secretion. Its active substances include an oxytoxic principle and a vasopressor or an antidiuretic principle. Our interest in these hormones has been almost entirely limited to the latter.

The purpose of the present report is to record our experiences in the treatment of hypertension, and menstrual headache which we have found to be associated with antidiuretic substance in the blood.

Treatment by irradiation of non-nephritic hypertension is not new. Delario and Meyers[7] and Hutton and Madden[22] have recently reported encouraging results following pituitary and adrenal irradiation. The latter, using small doses (50 r to each side of the head) observed a drop in blood pressure in almost half of the 234 patients treated. Delario and Meyers treated 177 patients with even better results (improvement in 75 per cent). Borak[2], however, using much larger doses (600 r to each field), observed no effect in patients with essential hypertension.

The treatment of patients with severe menopausal and menstrual discomfort by irradiating the hypophysis has also been previously reported. Borak[2,3] has contributed much to our knowledge of this type of therapy. His results have been definitely encouraging, as have the results of Huet and Sobel.[20]

We have irradiated the pituitary glands of 41 patients, 31 of whom had high blood pressure. The remaining 10 patients complained of symptoms referable to the menopause or menstruation. In almost each instance blood studies for antidiuretic substance were positive prior to irradiation. Repeated antidiuretic studies were then carried out at various periods during and after irradiation for comparison.

The test for blood antidiuretic substance, described by Griffith, Corbit, Rutherford and Lindauer,[17] is based upon the method developed by Burn[5] for assaying the antidiuretic content of posterior lobe extracts.

METHOD

No special preparation of the patient is required prior to venipuncture. About 10 cc. of blood is drawn and allowed to clot. The serum may be separated by centrifuging when necessary.

Adult rats are taken from the cage where dried food and water have been available as desired. Without anesthesia, rats are given 5 per cent of their body weight of water by stomach tube. The struggle of passing the tube always insures complete voiding. One cubic centimeter of the patient's serum is then injected intraperitoneally. The animal is then placed in a metabolic cage. The urine volume at the end of ninety minutes is then measured, complete voiding being assured by holding the animal and giving it a few whiffs of ether. The amount of urine voided is subtracted from the amount of water given and the difference is expressed in cubic centimeters retained per 100 gm. of body weight. It is apparent (Chart 1) that normal animals, with rare exceptions when given water alone, retain considerably less than 4 cc. per 100 gm. body weight. In view of this distribution a retention of 4 cc. or more per 100 gm. body weight has been decided upon as indicating positive evidence of antidiuretic substance in the blood. To assure

* From the Department of Radiology, the Robinette Foundation, and the Medical Clinic of the Hospital of the University of Pennsylvania. Read at the Forty-first Annual Meeting, American Roentgen Ray Society, Boston, Mass., Oct. 1–4, 1940.
† Atwater Kent Fellow in Medicine.

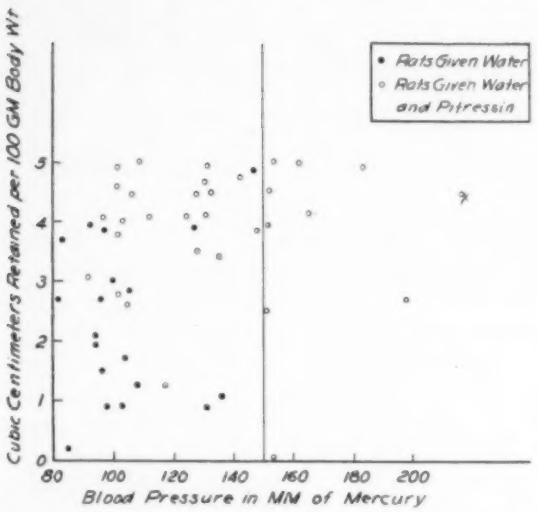

CHART I. Each dot or circle represents one animal. It will be noted that the only rats which developed high blood pressure were those which were given water and pitressin. It is also evident that many more of the rats given water and pitressin retained more than 4 cc. of fluid per 100 gm. of body weight than the animals which were given water alone.

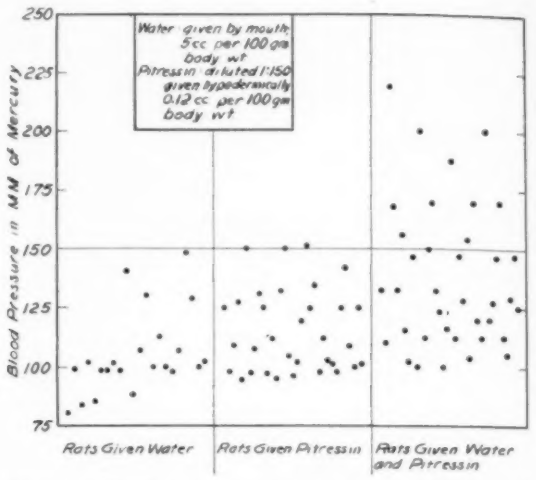

CHART II. Each dot represents one animal. It is evident that the animals given water and pitressin developed high blood pressure, whereas those given water or pitressin alone were unaffected.

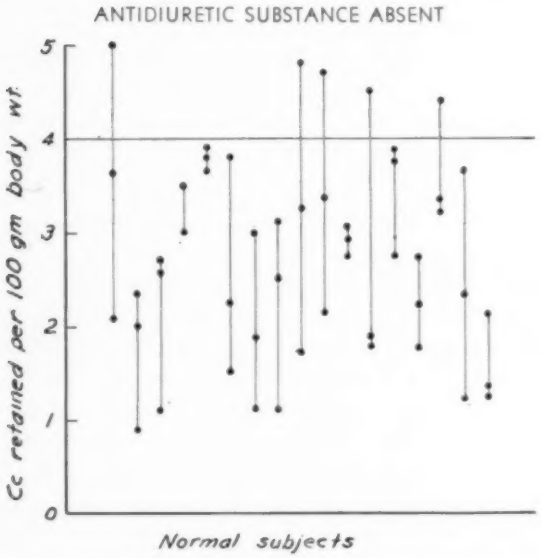

CHART III. Each perpendicular line represents one patient. Each of the three dots through which the perpendicular line passes represents the amount of fluid retained in each of the animals used. By definition, if two or more animals retained 4 cc. or more per 100 gm. of body weight the test was considered positive. This chart represents the findings in a group of normal individuals. None of the antidiuretic tests were positive.

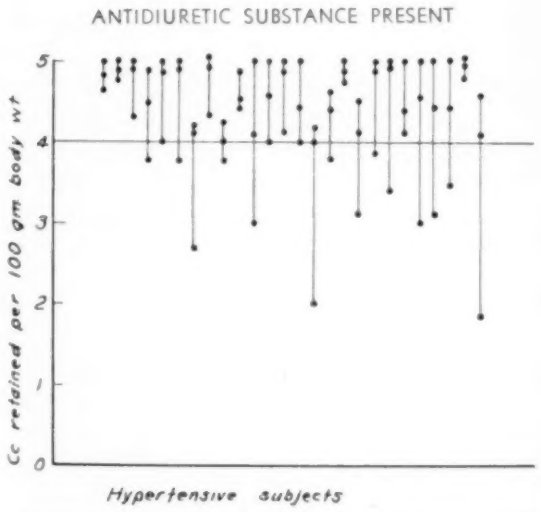

CHART IV. The blood of a large group of hypertensive individuals was examined for antidiuretic substance. All of the tests which were positive are included in this chart. Each perpendicular line represents one patient. Each of the three dots on each perpendicular line represents the number of cubic centimeters of water retained per 100 gm. of body weight. It is evident that much more fluid was retained per 100 gm. of body weight in each animal as compared to the distribution of these estimations in the normal subjects charted in Chart III.

less chance for error, the test has been carried out in triplicate.

Griffith, Roberts, Rutherford and Corbit[15] were able to produce antidiuresis and hypertension in rats by giving water by mouth and posterior pituitary substance, pitressin, by intraperitoneal injection (Charts I and II). Hypertension was not found if either the pitressin or water was given alone (Chart II). As the result of these experimental findings, Griffith and his associates investigated a large series of hypertensive patients for evidence of antidiuretic substance in the blood. The results were positive in many individuals, as Anselmino, Hoffmann and Kennedy[1] pointed out previously (Chart IV). In others, no antidiuretic substance was found (Chart V).

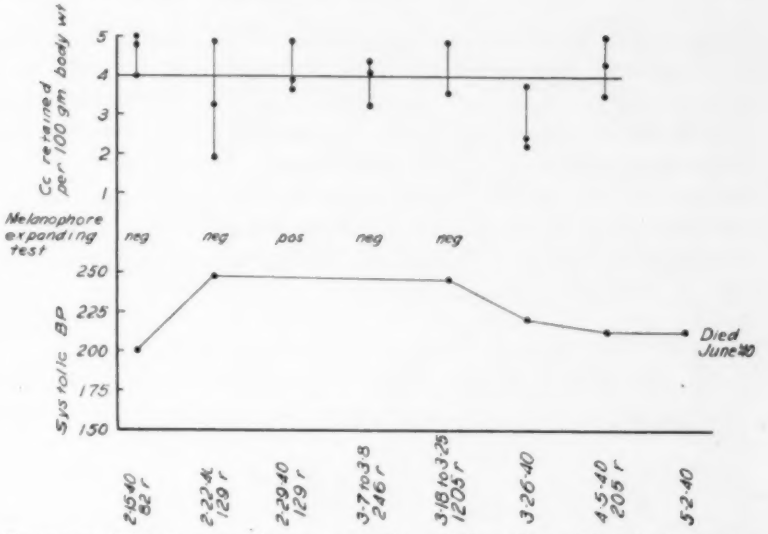

CHART VI. This is a graphic presentation of the effect of irradiation upon the blood pressure and blood antidiuretic substance in a patient with hypertension. At no time did the blood pressure approach normal. The antidiuretic test, which was positive in February, 1940, was rendered negative by the roentgen therapy delivered to the pituitary in March, 1940. It became positive again following which it again became negative when further irradiation was given. This patient had three diopters choking of the discs and in February, 1940, after hypophyseal irradiation, the choking of the discs entirely disappeared.

We decided to irradiate the pituitary in those patients with positive antidiuretic tests to determine if the test could be rendered negative, and if the clinical picture of hypertension could be affected.

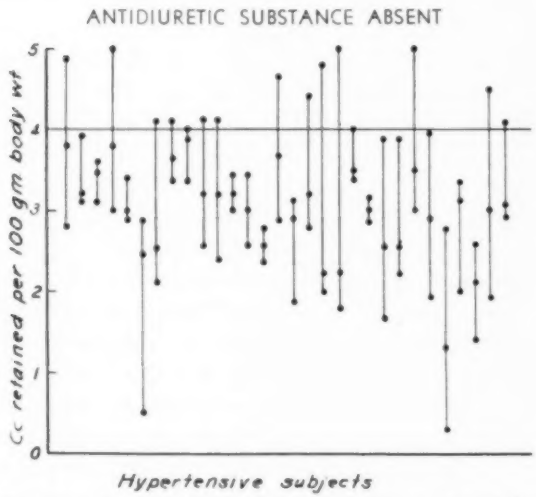

CHART V. Included in this chart are the results of the tests for antidiuretic substance in a group of hypertensive subjects in whom no evidence of antidiuretic substance was found in the blood.

HYPERTENSION

Thirty-one patients with hypertension were irradiated, treatment being directed into the hypophysis. No attempt was made to select the cases for treatment. The only prerequisite was a positive antidiuretic test. Thus patients with every stage of the disease were treated, the majority having headache, vomiting, papilledema, and renal or cardiovascular damage.

Results. Of the 31 hypertensive individuals irradiated, 7 have not been followed long enough to evaluate.

Eleven patients had little or no improvement following treatment. The course of the disease remained uninfluenced. In no instance did an untoward reaction develop following irradiation which could be attributed to the treatment. This was true when larger doses (200 r) as well as smaller

doses (50 r) were used daily. Two patients in this group died as the result of their disease.

Chart VI presents a graphic summary of the course of treatment and the changes effected in a patient whom we considered did not respond to hypophyseal irradiation. It demonstrates how the antidiuretic test may be rendered negative without influencing the blood pressure. It is noteworthy that the patient's papilledema subsided following treatment.

Eight patients showed considerable subjective improvement without any drop in blood pressure. The fact that the antidiuretic test became negative in many of these individuals led us to believe that the effect of hypophyseal irradiation was more than psychic.

Why the blood pressure remained elevated in these patients remains unexplained. It may be that much larger doses than 1,600 r are necessary in certain cases. Perhaps, as Walker[29] has pointed out, there are sources other than the hypophysis for antidiuretic substances which have not been treated.

In 5 patients the effect of hypophyseal irradiation was very encouraging. The clinical symptoms disappeared and the blood pressure dropped 50–75 mm. of mercury. The average amount of radiation delivered to the hypophysis was essentially the same as that given those patients in whom less favorable results were obtained. It is noteworthy that the antidiuretic test became negative in 4 of these 5 patients following pituitary treatment.

Chart VII presents graphically the effect of treatment in a typical case. The total dose employed is somewhat higher than we now use.

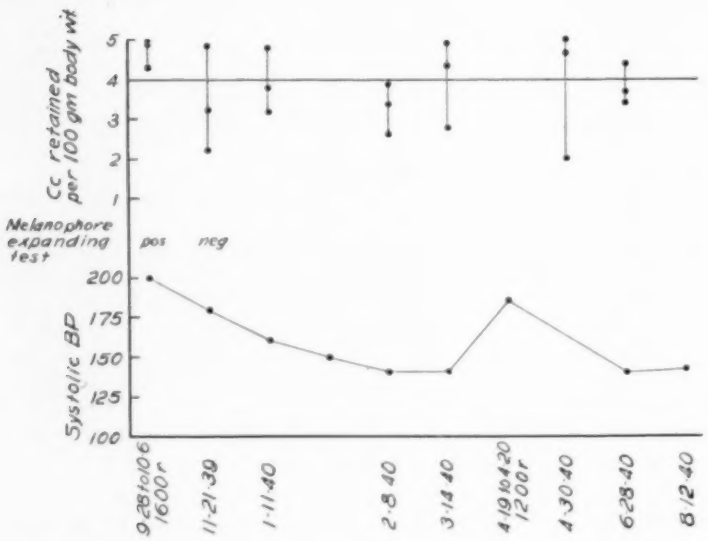

CHART VII. This is a graphic presentation of a favorable response in a patient with hypertension. The antidiuretic substance which was positive became negative following treatment. Blood pressure also dropped. In March, 1940, the antidiuretic substance was again found in the blood but it was not until one month later that the blood pressure became elevated. High voltage irradiation delivered to the hypophysis again produced a drop in blood pressure and the disappearance of antidiuretic substance from the blood.

Technique. We used rays generated at 200 kv., filtered through 0.75 mm. Cu plus 2 mm. Al, at a target-skin distance of 50 cm., the portal being 7 cm. in diameter. Two temporal portals are used, one portal being treated daily. The daily dose varied from 50 to 200 r.* During the early course of our investigation the daily dose was maintained at 50 r. With experience we have found that patients tolerated an increase of 50 r per day until 200 r is delivered to one portal daily. The total dose has also varied considerably. A review of our protocols suggested that a total of 400 to 500 r applied to the skin usually sufficed for the first series. In our experience it has been unusual for higher total doses to produce a favorable response if 400 to 500 r has been ineffective. In addition, it seemed to make

* Roentgens measured in air without backscatter and applied to the skin.

little difference in the promptness with which the test was rendered negative and patients reported clinical improvement as to whether the total dose used was 500 r or closer to 1,000 r. The duration of the beneficial effect also seemed little influenced by doses higher than 500 r.

It is still too early to tell how long the beneficial effects of roentgen therapy will last. Most of our patients have been followed only four to six months. We believe that four to six weeks must elapse following a series of pituitary treatments before one can evaluate results. If at this time no change in the patient's condition has been noticed a second series of treatments may be resorted to, the total dose in the second series approximating 1,000 r. Whether more than two series of treatments should be resorted to in unfavorable cases is questionable. The evidence suggests that patients with definite renal damage will not be benefited by the procedure.

CATAMENIAL FLUID RETENTION

It is not uncommon for women to complain of severe headache, thirst, or abdominal puffiness during the premenstrual period of their cycle. In addition it is well recognized that such discomfort frequently subsides with the onset of menstrual flow. There is good evidence that these symptoms may be due to local or generalized edema resulting from disturbed mineral and water metabolism incident to the catamenia.[23,25]

It has been demonstrated that a retention of sodium, chloride and water develops during the intermenstrual and premenstrual stages of the normal female cycle.[27] With the onset of the menses this process reverses itself and increased urinary excretion ensues. Indeed, Thorn, Nelson and Thorn[27] found that 24 of 50 normal women gained an average of 2.2 pounds in weight during the premenstrual stage which was rapidly lost following the onset of menstrual flow. This physiological reversible reaction is probably due to antidiuretic hormone activity with fluid retention.

The antidiuretic properties of posterior pituitary lobe extracts have been amply demonstrated[4,12,26] and the control of diuresis in diabetes insipidus by the use of pitressin serves as an excellent example of this effect. Burgess, Harvey and Marshall[4] concluded that this diuresis inhibition could be attributed to the action of the antidiuretic hormone upon the tubular epithelium of the kidney. Those authors believe that as a result of this activity greater quantities of glomerular filtrate were absorbed in the loops of Henle and therefore less urine was eliminated.

The observations recounted above suggested to us that the blood of women complaining of menstrual symptoms might contain antidiuretic substance. The test was positive in almost every such patient studied, providing the blood was withdrawn within several days of the onset of the menses. With experience we have found that blood examinations made within two weeks after the cessation of menstrual flow may reveal no evidence of antidiuretic substance. In view of this physiological fluctuation all antidiuretic tests in patients with menstrual symptoms are now made within several days of the onset of menstruation.

Why menstruating women develop headaches is a moot question. Some authors have suggested that increased intracranial pressure incident to fluid retention may be responsible. Others[10] believe that the hypophysis becomes engorged suddenly during the premenstrual period thereby stretching the diaphragma sellae, causing pain. That this latter explanation may be a factor is suggested by the absence of antidiuretic substance in some women with intense menstrual headaches. It is because all menstrual headaches may not be due to increased fluid retention that we routinely irradiate the hypophysis of women complaining of these symptoms, often in the absence of a positive antidiuretic test.

Results. We have treated 10 patients with symptoms thought to be attributable to catamenial fluid retention. Of these, 3 have

not been followed long enough to evaluate. Five patients were treated for intense menstrual headache. In 3 instances there was marked relief of pain. One patient was moderately improved. One patient was unaffected by the treatment. The antidiuretic test which was positive in 5 of the patients prior to hypophyseal irradiation was not always influenced by the treatment, indeed the test remained positive in three. Perhaps the amount of treatment employed was not sufficient to reverse the biologic test, but until more is known about the effect of irradiation on the hypophysis we shall continue to use minimal doses.

Chart VIII is a graphic presentation of the manner in which a patient with severe menstrual headaches was treated. The rapid relief of symptoms following roentgen therapy is well demonstrated. It is of interest that this patient subsequently developed a positive antidiuretic reaction which was again rendered inactive by further irradiation. In our experience the antidiuretic test frequently becomes positive about one month before the patient complains of a recurrence of the clinical symptoms.

Two patients received hypophyseal irradiation because of recurring monthly edema of the legs which seemed related to the menstrual function. The swelling started ten to fourteen days prior to the onset of the menstrual flow. With the occurrence of menstrual bleeding the peripheral edema rapidly regressed. Symptoms of this character which develop in menstruating women seem to have been explained by the observations of Thorn, Nelson and Thorn.[27]

The blood of our 2 patients was investigated for antidiuretic substance. In both instances the test was positive.

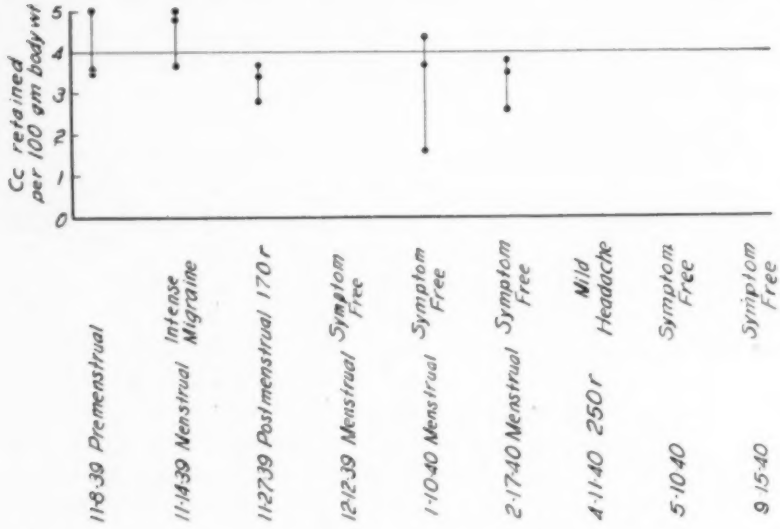

CHART VIII. This is a graphic presentation of a favorable response obtained in a patient complaining of intense menstrual headaches. Three tests for blood antidiuretic substance were made in November, 1939. The premenstrual and postmenstrual tests were negative. The tests made during the period of menstrual flow were positive. This demonstrates the importance of withdrawing blood just prior to the menstrual period in patients complaining of catamenial fluid retention.

The observations in these patients are similar to those made by Edeiken and Griffith[9] in a patient treated for recurring pulmonary edema by means of hypophyseal irradiation. For months the latter patient suffered from acute pulmonary edema which developed just prior to the menstrual flow and subsided soon thereafter. The antidiuretic test was positive. The symptoms suggested catamenial fluid retention. The hypophysis was irradiated and an excellent result obtained.

We treated the hypophysis in the 2 patients with lower limb edema. An excellent result was obtained in one, but there was little evidence of improvement in the other. In neither individual was the antidiuretic test rendered negative by the hypophyseal irradiation.

Chart IX is a graphic presentation of the manner in which the patient who responded to irradiation was treated.

Technique. We have used rays generated

at 200 kv., filtered through 0.75 mm. Cu and 2 mm. Al, at a target-skin distance of 50 cm. the portal measuring 7 cm. in diameter. As a rule, patients with symptoms due to a menstrual fluid retention are treated from seven to ten days prior to the onset of menstrual flow.

The daily dose varied from 50 to 100 r, one portal being treated at a sitting. In our experience 300 to 500 r sufficed to control the menstrual headache. A similar dose was used in the patient with edema in the lower limbs who responded to therapy.

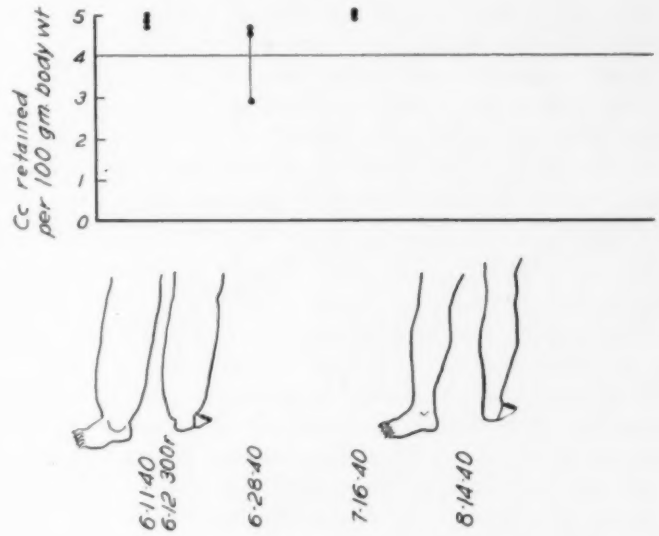

CHART IX. This is a graphic presentation of the favorable response obtained in a patient with edema due to catamenial fluid retention. It is interesting that the antidiuretic test did not become negative following high voltage irradiation. The sketch of the lower limbs, demonstrating marked edema in June, 1940, represents the appearance of the legs just prior to menstruation. The more normal appearing lower limbs represent the loss of edema which was evident after treatment.

These patients have been followed for only about six months. It is therefore too early to state how long the beneficial effects of hypophyseal irradiation persist. We have not hesitated to give a second course of irradiation two months later if the first series proved ineffective. In such instances the total dose given during the second series approximated 400 to 500 r.

Antidiuretic tests were made at repeated intervals following hypophyseal irradiation, for fluid retention, care being taken to use blood which was withdrawn each time during the same phase of the menstrual cycle. There was no uniformity in the results obtained with reference to the antidiuretic test. In some individuals the antidiuretic test remained positive, in others it was unaffected. We could find no relationship between the degree of clinical improvement and the effect upon the antidiuretic substance.

DISCUSSION

We have irradiated the hypophyses of a small group of patients with clinical improvement in approximately half of the cases. Much larger groups with hypertension or menstrual headaches have been treated by others with equally good or better results.[7,11,21]

In about two-thirds of our patients, positive antidiuretic tests were rendered negative by irradiating the pituitary. This seems important as it suggests that there may exist, in the region of the hypophyseal fossa, a center or centers which partially control blood antidiuretic substance. There is good evidence that the pars neuralis (posterior lobe) liberates the antidiuretic substance.[4,8,12,26,28] Others[11,24] believe the hypothalamus and its supra-optic nuclei may be related to this function, although Van Dyke[28] believes that the latter hypothesis remains to be proved. From the roentgen therapeutic standpoint it makes little difference which is the control area as both are included in the field of irradiation.

In comparing the group of patients irra-

diated for hypertension with the group treated for catamenial fluid retention, it was evident that a larger percentage of positive antidiuretic tests were rendered negative in the hypertensive group than in the catamenial group. This difference may be attributed in part to the larger doses of radiation used in the treatment of hypertension. The evidence suggests that as the dose is increased to about 500 r more positive antidiuretic tests will become negative. In some individuals the test may become negative with 80 r delivered to the skin of the temple, whereas doses as high as 1,600 r have no effect in others.

The observation, that total doses of less than one erythema when applied to the skin of each temporal region may frequently reverse a positive antidiuretic reaction, suggests that the tissues affected are radiosensitive. Cushing,[6] examining the pituitary glands of patients dying of hypertension, found varying degrees of basophilic infiltration in the posterior lobe. One might suggest that the beneficial effects observed in our patients were in part, at least, due to the effect of irradiation upon the basophilic infiltration, as it is known that basophilic hypophyseal tumors are radiosensitive.

The present communication must be considered a preliminary report. The work has been carried on for almost one year. Much more investigation and a greater number of cases will be necessary before the value of the antidiuretic tests in the treatment of hypertension and catamenial fluid retention can be evaluated.

SUMMARY

1. Thirty-one patients with high blood pressure and ten patients with symptoms due to catamenial fluid retention were irradiated.

2. Approximately one-half of this group were benefited by hypophyseal irradiation.

3. Blood studies for antidiuretic substance were obtained before, during and after treatment in most individuals.

4. Positive blood studies for antidiuretic substance were rendered negative in almost two-thirds of the hypertensive patients who were benefited by hypophyseal irradiation.

5. Positive blood studies for antidiuretic substance were rendered negative in almost one-third of the patients treated for catamenial fluid retention by hypophyseal irradiation.

6. The possible relationship between the antidiuretic substance in the blood, the pituitary irradiation, and the clinical symptoms are discussed.

REFERENCES

1. Anselmino, K. J., Hoffmann, F., and Kennedy, W. P. Relation of hyperfunction of the posterior lobe of hypophysis to eclampsia and nephropathy of pregnancy. *Edinburgh M. J.*, 1932, *39*, 376–388.
2. Borak, J. Roentgen therapy of symptoms of the climacteric. *Strahlentherapie*, 1929, *33*, 142.
3. Borak, J. Treatment of hyperthyroidism by roentgen irradiation of pituitary gland. *Radiology*, 1935, *24*, 535–549.
4. Burgess, W. W., Harvey, A. M., and Marshall, E. K., Jr. Site of antidiuretic action of pituitary extract. *J. Pharmacol. & Exper. Therap.*, 1933, *49*, 237–249.
5. Burn, J. H. Estimation of antidiuretic potency of pituitary extract. *Quart. J. Pharm. & Pharmacol.*, 1931, *4*, 517.
6. Cushing, Harvey. Hyperactivation of neurohypophysis as pathological basis of eclampsia and other hypertensive states. *Am. J. Path.*, 1934, *10*, 145–176.
7. Delario, A. J., and Meyers, F. R. Deep roentgen ray therapy in treatment of disturbances of autonomic system. *J. Med. Soc. New Jersey*, 1935, *32*, 287–297.
8. Dieckmann, W. J., and Michel, H. L. Vascular-renal effects of posterior pituitary extracts in pregnant women. *Am. J. Obst. & Gynec.*, 1937, *33*, 131–137.
9. Edeiken, J., and Griffith, J. Q., Jr. Cyclic pulmonary edema at menses in mitral stenosis. *J. Am. M. Ass.*, 1940, *115*, 287–289.
10. Fichera, G. On the hypertrophy of the pituitary gland following castration. *Arch. ital. biol.*, 1905, *43*, 405.
11. Fisher, C., Ingram, W. R., and Ranson, S. W. Relation of hypothalamico-hypophyseal septum to diabetes insipidus. *Arch. Neurol. & Psychiat.*, 1935, *34*, 124–163.
12. Gilman, A., and Goodman, L. S. Secretion of an antidiuretic hypophyseal hormone in response to need for renal water conservation. *Science*, 1936, *84*, 24–25.
13. Griffith, J. Q., Jr., Roberts, E., and Corbit, H. O. Studies of criteria for classification of

arterial hypertension. I. Cutaneous capillaries. *Am. Heart J.*, 1941, *21*, 47–53.

14. Griffith, J. Q., Jr., Roberts, E., and Corbit, H. O. Studies of criteria for classification of arterial hypertension. II. Minute vessel pressure. *Am. Heart J.*, 1941, *21*, 54–61.
15. Griffith, J. Q., Jr., Roberts, E., Rutherford, R. B., and Corbit, H. O. Studies of criteria for classification of arterial hypertension. III. Cutaneous lymphatic flow. *Am. Heart J.*, 1941, *21*, 62–66.
16. Griffith, J. Q., Jr., Rutherford, R. B., Roberts, E., and Lindauer, M. A. Studies of criteria for classification of arterial hypertension. IV. Blood volume. *Am. Heart J.*, 1941, *21*, 67–76.
17. Griffith, J. Q., Jr., Corbit, H. O., Rutherford, R. B., and Lindauer, M. A. Studies of criteria for classification of arterial hypertension. V. Types of hypertension associated with the presence of posterior pituitary substance. *Am. Heart J.*, 1941, *21*, 77–89.
18. Griffith, J. Q., Jr., Lindauer, M. A., Roberts, E., and Rutherford, R. B. Studies of criteria for classification of arterial hypertension. VI. Treatment with thiocyanate. *Am. Heart J.*, 1941, *21*, 90–93.
19. Griffith, J. Q., Jr., Fry, W. E., and Roberts, E. Studies of criteria for classification of arterial hypertension. VII. Increased intracranial pressure and papilledema. *Am. Heart J.*, 1941, *21*, 94–97.
20. Huet, J. A., and Sobel, A. Note on the roentgen irradiation of the hypophysothalamic region. *Bull. et mém. Soc. de radiol. méd. de France*, 1930, *18*, 306.
21. Hutton, J. H., Culpepper, W. L., and Olsen, E. C. Response of essential hypertension and diabetes mellitus to small doses of x-ray. *Arch. Phys. Therapy*, 1936, *17*, 7–14.
22. Hutton, J. H., and Madden, E. E. Low dosage irradiation of pituitary and adrenals for treatment of non-nephritic hypertension. *Illinois M. J.*, 1936, *70*, 125–131.
23. Krohn, P. L., and Zuckerman, S. Water metabolism in relation to menstrual cycle. *J. Physiol.*, 1937, *88*, 369–387.
24. Page, I. H., and Sweet, J. E. Extirpation of pituitary gland on arterial blood pressure of dogs with experimental hypertension. *Proc. Soc. Exper. Biol. & Med.*, 1936, *34*, 260–262.
25. Petersen, W. F., and Milles, G. Relation of menstruation to permeability of skin capillaries and autonomic tonus of skin vessels. *Arch. Int. Med.*, 1926, *38*, 730–735.
26. Rutledge, D. I., and Rynearson, E. H. Diabetes insipidus; treatment by insufflations of powdered posterior pituitary substance. *Proc. Staff Meet., Mayo Clin.*, 1939, *14*, 443–446.
27. Thorn, G. W., Nelson, K. R., and Thorn, D. W. Study of mechanism of edema associated with menstruation. *Endocrinology*, 1938, *22*, 155.
28. Van Dyke, H. B. The Physiology and Pharmacology of the Pituitary Body. Vol. II. University of Chicago Press, Chicago, 1939.
29. Walker, A. M. Experiments upon relation between pituitary gland and water diuresis. *Am. J. Physiol.*, 1939, *127*, 519–540.

DISCUSSION

Dr. John Rock, Boston. It is a great pleasure to be allowed to discuss this well constructed paper describing such rationally conceived therapeutic experiments. I regret I cannot throw more light on the subject. The authors are dealing with several imponderables: the puzzling pituitary, including not only the posterior portion which apparently does secrete a pressor and antidiuretic principle, but also the anterior portion, which secretes the gonad-stimulating hormones. Which cells in each portion of the gland do what, and what their relative susceptibility to roentgen rays is, we do not always know. The roentgen rays themselves, this invisible magical force, just what do they do to the cells of the pituitary which are struck? Destruction of at least some seems likely. If these cells are trouble makers, that is good. Hypertension, the authors make clear, is due to many causes not related to antidiuresis or to the posterior hypophysis. And then there is the premenstrual retention of electrolytes and of water. This retention has been shown to be closely related to the increase in concentration of sex hormones in the blood, and to occur when the hormone content is high, and to decrease suddenly as the hormones diminish. I mention these imponderables to explain partially my inability to be specific in discussion of the results presented.

In my clinic, we have furtively used roentgen rays in an effort to affect ovarian function. We used doses only of three or four times 50 r, given at weekly intervals, at first to both ovarian and pituitary fields. Because I thought that little if any of the roentgen rays as given reached through the skull to the pituitary, I soon confined myself to treatment of only the ovaries, and saw no difference in the results obtained, which were clinically good. Stimulated by the authors, I shall now try treatment only of the pituitary, for probably the anterior as well as the posterior gland is susceptible. There will at least be one great advantage in irradiating only the pituitary, if that suffices. It will avoid two

never to be forgotten dangers in irradiation, with however small a dose, of the germinal epithelium: the danger of establishing the menopause and if not that, the danger of disturbing the genes of the otherwise unharmed germ cells. It is true that the offspring of irradiated mothers are apparently normal. Genetic research with many species leads us to fear that subsequent descendants who have two irradiated grandmothers may not be so good.

Dr. Pendergrass's paper confirms the demonstration that roentgen rays will usually diminish the concentration in the blood of an unidentified antidiuretic factor. Three out of 5 patients with premenstrual headaches were relieved, apparently without regard to the effect on the pressor principles. Until we know more about roentgen-ray effects, we shall try to relieve headache by drugs and use roentgen irradiation when these fail. But there is no dependable treatment beyond restriction of sodium chloride and of water for premenstrual edema. The 50 per cent of cures in the 2 cases discussed gives me encouragement, and I have complete willingness to hope that with more cases the cure rate will stay as high.

Vol. 46, No. 5

FURTHER STUDIES IN THE RADIUM TREATMENT OF CARCINOMA OF THE UTERINE FUNDUS*

By ROBERT E. FRICKE, M.D., *and* HARRY H. BOWING, M.D.
Section on Therapeutic Radiology, Mayo Clinic
ROCHESTER, MINNESOTA

OF ALL internal malignant lesions, carcinoma of the uterine fundus has probably the most favorable prognosis. It is a postmenopausal disease, in contrast to carcinoma of the uterine cervix, which occurs in most instances about the time of the menopause. While carcinoma of the fundus is a very common disorder, the incidence in our experience at the Mayo Clinic is 1 case of carcinoma of the fundus to 3 of the more dangerous cancers of the uterine cervix.[8]

The lesser degree of malignancy of carcinoma of the fundus is probably due to several factors. On microscopic examination the lesion is usually of Grade 1 or 2, according to Broders'[3,4] classification; this means a more slowly growing cancer which metastasizes late in comparison with malignant lesions of Grades 3 and 4. That carcinoma of the fundus usually occurs in older patients than carcinoma of the cervix, for example, is well known. In older people a malignant lesion as a rule grows at a slower rate and affords more time for the physician to treat and arrest the process. Probably connected with this fact, diminution of the blood and lymph circulation of the generative organs after the menopause may retard the occurrence of distant metastasis. Also, the enclosure, almost encapsulation, of the cancer within the strong muscular walls of the uterus restricts direct spread of the lesion.

All these factors of lessened malignancy of carcinoma of the uterine corpus favor surgical extirpation of the cancer with less chance of recurrence or metastasis. A less radical surgical procedure usually will suffice to obtain a cure than is necessary for cancers in other locations. When the lesion is discovered fairly early in a case in which the patient is in good general condition, the treatment of choice is undoubtedly surgical.

However, radiologists have considerable interest in the treatment of this condition. There is a choice of treatment, especially in three classes of cases. The first class is the extensive, so-called inoperable carcinoma of the fundus, diagnosed late and too widespread for complete excision. This class we shall have always with us and limited radiation therapy always can yield worthwhile palliation, and occasionally a cure even in this group. The second class consists of cases in which the lesions are relatively small but in which the poor general condition of the patient or the presence of serious unrelated coexisting disease renders major operation a decidedly hazardous procedure. Radiologists are more interested in this second class, as well-planned radiation therapy may produce cures without any appreciable risk. The third class consists of cases in which complete hysterectomy is indicated. In these cases preoperative or postoperative irradiation is always valuable in increasing the number of cures and preventing recurrence.

Ten years ago at the annual meeting of this Society we analyzed the results of radium treatment of all patients with carcinoma of the fundus treated at the Mayo Clinic from the beginning of irradiation at the Clinic in 1915 to 1928, inclusive. The five year cure rate among patients treated with irradiation alone was 12.63 per cent.[1]

For the present study we have reviewed a later series, the patients treated at the Mayo Clinic with irradiation alone during the eleven year period from 1925 to 1935, inclusive.

* Read at the Twenty-sixth Annual Meeting, American Radium Society, Cleveland, Ohio, June 2–3, 1941.

AGE, SYMPTOMATOLOGY AND CONCURRENT DISEASE

Three hundred and thirty patients who had carcinoma of the uterine fundus were treated at the Mayo Clinic during the period 1925 to 1935, inclusive. In 115 cases, roughly a third of the total, the patients received radiation treatment alone. Ninety-five per cent of this latter group of 115 cases were traced and our studies are based on these 109 cases.

The youngest patient was thirty-seven years of age, the oldest eighty-three years; the average age on admission was 60.6 years.

TABLE I

GENERAL CONDITION OF THE PATIENT

Principal Concurrent Disease	Patients Treated		Lived 5 Years	
	Number	Per cent	Number	Per cent
Obesity	29	27	10	34
Hypertension	17	15	9	53
Cardiovascular	14	13	5	36
Secondary anemia	10	9	3	30
Diabetes	6	6	4	67
Miscellaneous*	7	6	1	14
None	26	24	10	38
Total	109	100	42	39

* Miscellaneous: gastrointestinal 2, renal 1, syphilis 1, goiter 1, paralysis agitans 1, severe old pelvic inflammatory disease 1.

The principal presenting symptom of the 109 cases was as follows: vaginal bleeding in 87, leukorrhea in 19, vaginal hemorrhage in one, pain in two. Any vaginal bleeding beyond the menopausal age certainly indicates immediate diagnostic curettage if the cervix and vaginal walls appear normal. A vaginal discharge also demands careful investigation. There is little excuse for a late diagnosis of carcinoma of the fundus if patients can be impressed with the fact that postmenopausal bleeding is often a symptom of serious disease, always demanding investigation, and that delay may be fatal.

Poor general condition of the patient or the presence of a serious disease unrelated to the malignant lesion is often the deciding factor between surgical treatment and radiation therapy without surgical treatment. Approximately three-fourths of the 109 patients had serious concurrent disease as well as cancer, as shown in Table 1. Since the lesions of about 40 per cent of these patients were of Stage I or II, according to the extent of the malignant disease, the presence of the unassociated disease had much weight in contraindicating major surgical intervention. Thus, if the radiologist can treat many of these patients successfully, he can lessen the burden of risk for the surgeon who is confronted with a major operation on a patient with a small malignant lesion but with other serious degenerative disease. In Table 1 it is to be noted also that cures were higher than the general average among patients who had serious hypertension and among patients who had diabetes mellitus.

TECHNIQUE OF RADIUM THERAPY AND RISK OF TREATMENT

Six years ago we reported our dosage and technique in the radium treatment of carcinoma of the uterine fundus.[2] Briefly, we employ an intensive broken-dose method with the purpose of applying homogeneous irradiation throughout the entire uterine and cervical canals. The entire canal is treated carefully, as the exact extent of the growth cannot be determined and it is safer to treat the entire canal. Tubes containing 50 millicuries of radon, with brass and silver filtration, are employed, using two tubes in tandem in the intra-uterine applications. The intra-uterine applications start in the depth of the fundus, and successive treatments irradiate the mid and the anterior fundal regions. The number of intra-uterine applications depends on the length of the uterine canal. The cervical canal is irradiated also and heavily filtered and well protected tubes are also applied in the vaginal cavity. Thus a moderately advanced lesion may receive 5,000 or 6,000

mc-hr. of intra-uterine treatment, around 1,400 mc-hr. in the cervical canal and 2,100 mc-hr. in the vaginal cavity. The treatments are given over a period of two or three weeks, treatments two or three times a week.

The course of treatment is followed by roentgen therapy around the pelvis, usually four fields in all, treating one area a day. However, the radium in direct contact with the cancer provides the bulk of the treatment. The roentgen treatment is a valuable accessory but plays a secondary rôle. On studying the 109 cases, we noted that in a third of the total group roentgen treatment had not been given for various reasons. The five year cures, however, showed the same percentage of cures for the patients receiving both radium and roentgen treatment and those receiving radium treatment alone.

Many techniques have been developed by radiologists to improve the results of radiation therapy, from the multiple tube technique of Heyman and the Y-shaped intra-uterine applicator of Schmitz and Schmitz to the hysterostat elaborated by Friedman. Many of these ingenious instruments are flexible and adaptable and provide good results in the hands of their designers. However, we have never felt justified in changing from the repeated brass tandem technique as this seems the simplest implement to adapt to a varying cavity. The diseased uterine fundus is often irregular and the canal tortuous; the uterine walls may be friable and very easily punctured. Our main principle in applying treatment is avoidance of trauma; to this end the patient is treated in the knee-chest position and the brass tandem on wire is inserted very gently at varying depths in the fundus.

Inasmuch as the lesions were classified as Stage III or IV in 65 of the 109 cases and as two or three weeks were required to complete the treatment, it is not surprising that serious complications occurred in 10 cases.

We have three main classifications of treatment: "complete" when a full course of treatment is outlined with definite hope of cure of the cancer; "limited" treatment with palliation in view in a case in which the prognosis is judged to be hopeless; and "abandoned" when the treatment outlined has had to be discontinued because of weakness of the patient or the development of serious complications. Sometimes, to our surprise, cure is obtained even with only limited treatment. In the series of cases under discussion only 60 per cent of the patients received complete radium treatment (Table II).

TABLE II

RADIUM TREATMENT
CARCINOMA OF THE UTERINE FUNDUS
1925–1935, INCLUSIVE

Treatment	Patients		Lived 5 Years	
	Number	Per cent	Number	Per cent
Complete	66	60	31	47
Limited	40	37	11	28
Abandoned	3	3	0	—
Total	109	100	42	39

Serious complications occurred in 10 cases, or 9 per cent. Hospital deaths were 3, or 2.6 per cent of the total group. These figures are based on all 115 patients treated, including 6 not traced to the five year limit. The serious complications consisted of pyometritis in 4 instances, phlebitis in 3, peritonitis and pelvic cellulitis in one each, and subdiaphragmatic abscess and bacteriemia in one. The patient who had peritonitis and the patient who had subdiaphragmatic abscess and bacteriemia died, as well as a third patient who succumbed to a cardiac condition. Thus, there were a total of 3 hospital deaths and of these 2 were connected with the malignant lesion or the treatment.

STAGE OF THE LESION AND THE PROGNOSIS

The plan of treatment must be determined by careful estimation of the general

condition of the patient and the extent of the malignant process at the time of admission. Undoubtedly, as emphasized by Ward and Sackett, and others, the extent of the disease or "stage" is the most important single prognostic factor. Unfortunately, the growth is not as accessible to inspection and palpation as carcinoma of the cervix, and determination of the stage is a tedious procedure. In carcinoma of the cervix we follow the classification outlined by the League of Nations Radiological Sub-commission.[5] Carcinoma of the fundus we have classified similarly into four stages, depending on the anatomic extent of the growth. Elsewhere we have defined the stages at length.[2]

In brief, Stage I denotes a small lesion limited to the uterine cavity but not involving the internal os. The uterus is not enlarged and is freely movable. In Stage II the uterus usually is enlarged but still movable with or without infiltration of one parametrium. Stage III exhibits definite infiltration of one or both parametria with some degree of fixation of the uterus or with involvement of the cervix or vaginal walls with a small primary growth. In Stage IV the uterus is enlarged and fixed. There may be perforation of the uterine walls with or without massive parametrial infiltration, or involvement of the retroperitoneal or lumbar lymph nodes or of the ovaries, bladder, bowels or labia, remote metastasis, a fixed primary growth with extensive metastasis in the vaginal wall or general carcinomatosis.

Table III portrays the results of radium treatment of 109 patients traced at the end of three, five, seven and ten years after treatment, according to stage. The prognosis varies definitely with the stage of the lesion: 93 per cent of patients who had Stage I lesions obtained five year cures contrasted with 52 per cent in Stage II, 34 per cent in Stage III and 6 per cent in Stage IV. This ratio is maintained in the three, seven and ten year levels also. Our five year cure rate of 39 per cent in these 109 cases is much better than the 12.63 per cent of five year cures among patients treated by irradiation alone from 1915 to 1928, inclusive; however, in this present series about 40 per cent were of Stages I and II, compared with 21.5 per cent in the earlier series. Hence, in the present series we were treating much less extensive lesions than in the earlier series.

TABLE III

SURVIVAL RATES BY STAGE
CARCINOMA OF THE UTERINE FUNDUS 1925–1935

Stage	Patients Traced	Living 3 or More Years after Treatment*		Patients Traced	Living 5 or More Years after Treatment*		Patients Traced	Living 7 or More Years after Treatment*		Patients Traced	Living 10 or More Years after Treatment*	
		Number	Per cent		Number	Per cent		Number	Per cent		Number	Per cent
I	15	14	93	15	14	93	9	6	67	5	2	40
II	29	17	59	29	15	52	19	7	37	12	4	33
III	32	15	47	32	11	34	26	4	15	20	3	15
IV	33	4	12	33	2	6	24	1	4	20	0	—
Total	109	50	46	109	42	39	78	18	23	57	9	16

* Inquiry as of January 1, 1941. The study includes only those patients treated prior to 1936, that is, 1935 and earlier. The seven year group comprises only those patients treated seven or more years prior to the time of inquiry, that is, 1933 or earlier; the ten year group 1930 or earlier.

GRADE AND PROGNOSIS

The histopathology of the lesion is interesting; characteristic tissue was obtained in all but seven of the 109 traced cases in which the patient was treated by irradiation. Only 1 of the 7 patients obtained a five year cure, the others succumbing to cancer within the first five years. Seventy-five per cent of the total number of lesions were diagnosed adenocarcinoma and 11 per cent squamous cell epithelioma. Our five year results listed 43 per cent cures for adenocarcinoma and only 17 per cent for squamous cell epithelioma.

To our surprise, we found end-results of treatment to vary directly with the microscopic grade of the lesion. Thus five year results showed 79 per cent Grade 1, 33 per cent Grade 2, 25 per cent Grade 3, and 12 per cent Grade 4 survivals. In the predominantly low grade lesions supposed to be radioresistant and hence always better treated surgically, this is an interesting finding (Table IV).

Table IV

SURVIVAL RATES BY GRADE OF MALIGNANCY
CARCINOMA OF THE UTERINE FUNDUS 1925–1935

Grade	Patients Traced	Living 3 or More Years after Treatment*		Patients Traced	Living 5 or More Years after Treatment*		Patients Traced	Living 7 or More Years after Treatment*		Patients Traced	Living 10 or More Years after Treatment*	
		Number	Per cent		Number	Per cent		Number	Per cent		Number	Per cent
1	19	16	84	19	15	79	11	7	64	7	3	43
2	42	17	40	42	14	33	29	6	21	21	3	14
3	16	7	44	16	4	25	14	3	21	12	2	17
4	17	2	12	17	2	12	13	1	8	9	0	—
Not graded	15†	8	53	15	7	47	11	1	9	8	1	12
Total	109	50	46	109	42	39	78	18	23	57	9	16

* Inquiry as of January 1, 1941. The study includes only those patients treated prior to 1936, that is, 1935 and earlier. The seven year group comprises only those patients treated seven or more years prior to the time of inquiry, that is, 1933 or earlier; the ten year group 1930 or earlier.

† Includes 7 cases in which no tissue was obtained.

To our surprise, we found end-results of treatment to vary directly with the microscopic grade of the lesion. Thus five year results showed 79 per cent Grade 1, 33 per cent Grade 2, 25 per cent Grade 3, and 12 per cent Grade 4 survivals. In the predominantly low grade lesions supposed to be radioresistant and hence always better treated surgically, this is an interesting finding (Table IV).

CONCLUSIONS

In carcinoma of the uterine fundus one is dealing with a low grade type of cancer with the best prognosis of any internal malignant lesion. The slow growth and later metastasis indicate surgical treatment for all good surgical risks. Less radical surgical treatment is necessary than for cancers situated elsewhere.

Unfavorable features are that this type of cancer occurs in a later age group and many patients who have resectable lesions suffer also with serious unrelated diseases which greatly increase the surgical risk.

Radiation therapy is invaluable in increasing the five year favorable results when used in conjunction with major surgical treatment,[8] and also as a palliative agent in extensive inoperable cancers.

The stage and grade of the lesion are both important prognostic factors when irradiation alone is employed. The cure rate with radium treatment varies directly with the extent of the growth and also with the microscopic grade of the lesion.

Although low grade lesions always are considered radioresistant we find in this series that the lower grades have the best chance of cure.

We believe from this study that physicians have been too pessimistic about the cure of carcinoma of the fundus with radium alone; especially in cancers of low grade and small extent, carefully planned radiation treatment offers a good prognosis and, when the surgical risk is increased by poor general condition of the patient, much of the burden can be taken from the surgeon by employing radiation therapy.*

REFERENCES

1. BOWING, H. H., and FRICKE, R. E. Radium as an adjunct to surgery in the treatment of carcinoma of the fundus of the uterus. AM. J. ROENTGENOL. & RAD. THERAPY, 1931, *26*, 738–745.
2. BOWING, H. H., and FRICKE, R. E. Dosage and technique in the treatment of carcinoma of the uterine fundus with radium. AM. J. ROENTGENOL. & RAD. THERAPY, 1935, *33*, 50–53.
3. BRODERS, A. C. The grading of carcinoma. *Minnesota Med.*, 1925, *8*, 726–730.
4. BRODERS, A. C. The grading of cancer; its practical value. (Editorial.) *Am. J. Clin. Path.*, 1935, *5*, 254–256.
5. League of Nations, Health Organization, Cancer Commission: Report submitted by the Radiological Sub-Commission. Geneva. League of Nations Publications. 1929, 82 pp.
6. FRIEDMAN, MILTON. The treatment of carcinoma of the corpus uteri: description of a new hysterostat. *Radiology*, 1940, *35*, 28–35.
7. HEYMAN, J. The so-called Stockholm method and the results of treatment of uterine cancer at Radiumhemmet. *Acta radiol.*, 1935, *16*, 129–148.
8. MASSON, J. C. Carcinoma of the uterus. *New Orleans M. & S. J.*, 1939, *92*, 235–243.
9. SCHMITZ, HENRY, and SCHMITZ, H. E. An improved technique for radium treatment of carcinoma of the uterine body. AM. J. ROENTGENOL. & RAD. THERAPY, 1935, *34*, 759–765.
10. WARD, G. G., and SACKETT, N. B. Results of radiation therapy for carcinoma of the uterus at the Woman's Hospital, New York, 1915–1932. *J. Am. M. Ass.*, 1938, *110*, 323–326.

* For discussion see page 706.

Vol. 46, No. 5

PNEUMOPERITONEUM AS AN AID IN PELVIC IRRADIATION FOR CARCINOMA OF THE CERVIX*

By L. R. SANTE, M.D.
ST. LOUIS, MISSOURI

THE radiosensitivity of normal structures has always proved the limiting factor in radiation therapy. This is especially true of carcinoma of the cervix. The rather close limitation of effective radiation from radium in the cervical canal has proved an advantage to its use in treatment of the local growth, but a great disadvantage in the effectual irradiation of parametrial extensions. The operation of the inverse square law leads to the rapid falling off of radiation so that little reaches the parametrial tissues from the cervical application. To augment what little radiation reaches the parametrium from this source, supplementary radium treatments are given, with vaginal bomb, radium packs or a colpostat wherever these can be used. Of these, the radium bomb surely does not add greatly to the effective dosage in the parametrial region; the colpostat, where it can be properly applied, and vaginal packs deliver perhaps the greatest dosage that can be expected from vaginal application. In order to still further augment the dosage in the parametrium, interstitial irradiation with radium needles has been resorted to. The more or less blind insertion of numerous large radium needles into potentially malignant tissue in a location where there is no natural egress of the products of inflammation or tissue destruction has always seemed to me to be a greater hazard to the patient than the good which might be accomplished. The less trauma done to carcinomatous tissue, especially where the growth is confined and the pressure of drainage cannot easily be relieved to the outside, the better. At any rate, very few radiologists still adhere to this method and it has been largely discarded.

To further supplement the radium dosage delivered into the parametrium, roentgen irradiation is given, both externally and in recent years, intravaginally. To apply external irradiation to the parametrium through the abdomen or back, large amounts of normal tissue structures will be subjected to the same amount of radiation. The days of massive dose roentgen therapy have taught us of the sensitivity of the intestinal mucosa; animal experimentation and some disastrous human results have demonstrated this beyond question. With the divided dose methods now in use, the effect on the intestinal mucosa seems less evident, but there can be no doubt that some deleterious effects on the intestinal mucosa must result.

Any method, then, by which the intestines can be removed from the field of irradiation should be desirable. This we have attempted to do by the induction of pneumoperitoneum. With the patient in the Trendelenburg position, the air rises into the pelvis, enveloping the pelvic structures and displacing the intestines to the upper portion of the abdomen. The removal of practically all of the intestines from the field of irradiation serves not only to eliminate the deleterious effects of radiation on the normal structures, but also to remove the natural hindrance which these structures afford to passage of the rays. The Trendelenburg position without pneumoperitoneum has been advocated by a few authors (Pack and Livingston[1]); this undoubtedly causes some tendency to upward displacement of the intestines in a patient with a lax abdominal wall, but naturally the intestines cannot be displaced to any great extent unless they are given a place to go. In addition, the displacement of solid material from beneath the abdominal wall reduces by a certain amount the scattered radiation, which should permit the application of a some-

FIG. 1. After introduction of air into the peritoneal cavity roentgen examination is made with patient in the Trendelenburg position. With patient tilted about 50 to 60 degrees with head downward, the roentgen-ray beam directed straight downward is projected along the pelvic axis.

what higher skin dosage as applied externally. Obviously this amount would be greater in an individual with a thin abdominal wall than in one whose abdominal wall was thick. Lateral fields would probably derive the least advantage from the use of pneumoperitoneum.

Likewise, the removal of the underlying intestinal structures facilitates compression of the lower abdomen by a treatment cone. Compression alone is a great factor in increasing the relative depth dose so that in this case it may prove a material advantage. Obviously greater compression can be secured in a patient with a flabby fat abdominal wall, where it is needed the most, than in one with a thin tense muscular structure. With intravaginal roentgen irradiation the greatest advantage would seem to be the removal of small intestine from the field of irradiation, thereby permitting greater doses with impunity.

PROCEDURE

1. *Produce Artificial Pneumoperitoneum.* After evacuation of the intestinal tract, pneumoperitoneum is produced by a simple technique previously described.[2] Inflation is carried to a point somewhat greater than that ordinarily used for diagnostic pneumoperitoneum. The patient should be kept on her back in bed for the first day or so until she becomes accustomed to the presence of air in the abdomen. Pain in the back between the shoulders is the penalty of assuming the upright position during this time, but pain subsides immediately on lying down again. Air is used since large amounts of this gas usually require from ten to fourteen days for complete absorption, often providing sufficient time for carrying out the entire course of roentgen therapy with a single filling. At most, one refill about the seventh day is all that should be necessary under any circumstances. The widespread use of pneumoperitoneum in the treatment of pulmonary tuberculosis is evidence that air in the abdomen is well tolerated over long periods of time.

2. *Make Roentgen Examination.* (Fig. 1.) With the patient lying on the abdomen, head downward, on a tilt table lowered to an angle of about 45 to 50 degrees, the air

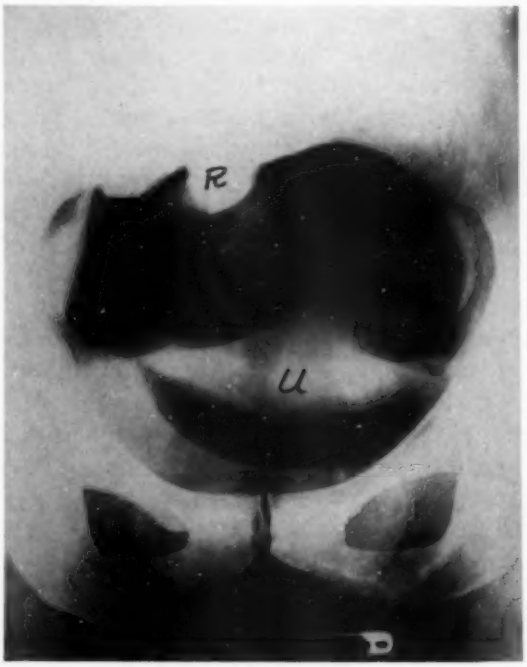

FIG. 2. Roentgenogram of pelvic structures made with patient in position shown in Figure 1. Note complete displacement of intestines from pelvis showing uterus, *U*, rectum, *R*, collapsed bladder, *B*.

rises to fill the pelvis, enveloping the pelvic organs and displacing the intestines. Roentgen examination of the pelvic organs is made by projecting the roentgen-ray beam along the pelvic axis, represented roughly by a line between the anus and umbilicus. When the patient lies on the face, hips elevated to this degree, the roentgen-ray beam will be almost straight downward; when the patient lies on the back in the same tilted position, the roentgen-ray beam must be directed downward to the feet, to a corresponding degree, in order to be projected along the pelvic axis.

The information received from this roentgen examination may be of value in the treatment of the patient (Fig. 2). The facts to be determined are the presence, position and size of the uterus, and location of the other pelvic organs. Any masses can be visualized and their relationship to the uterus and other pelvic structures noted. Of course it is not possible with any degree of consistency to determine the exact character of the pathologic condition. This examination will also determine whether the intestines have been completely displaced from the pelvic region and lower abdomen, or whether from adhesions or other cause they remain firmly in place in spite of pneumoperitoneum and the inverted position.

3. *Make the necessary measurements*, recording the thickness of the patient's body in the anteroposterior direction and along the pelvic axis, with the patient lying on her face as well as on her back. Record the contour of the patient's body at the level of the cervix by using a flexible lead strip or a physicist's variable curve.

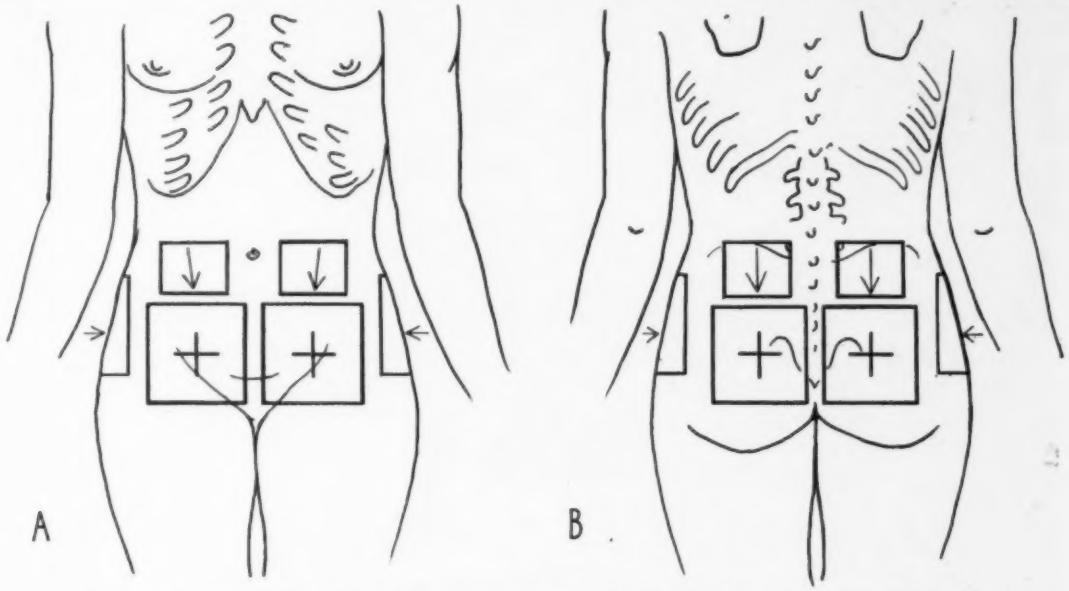

Fig. 3. *A*, outline four portals anterior, two on each side; *B*, four portals posterior, two on each side, and two lateral portals.

4. *Outline the portals for roentgen therapy* with the patient in the same inverted position in which treatment is to be carried out (Fig. 3), using four portals anteriorly, two on each side, and four portals posteriorly, likewise with two on each side, covering very closely the areas recommended by Arneson and Quimby.[3] The size of the lower portals should be 15 × 15 cm., or 10 × 10 cm., depending upon the size of the individual, with the roentgen-ray beam directed straight inward into the pelvis. The size of the upper portals should be 10 × 10 cm. with the roentgen-ray beam directed downward along the axis of the pelvis. It has been found advantageous to separate the

two upper fields 4 cm. in the midline and incline the beam back toward the midline about 10 degrees. All other fields should be 2 cm. apart in the midline. In addition to these, two lateral 10×15 cm. portals will add to the parametrial dosage. In this way (Fig. 4), at least four portals will be directed over each adnexal region from the anterior and posterior directions, and one

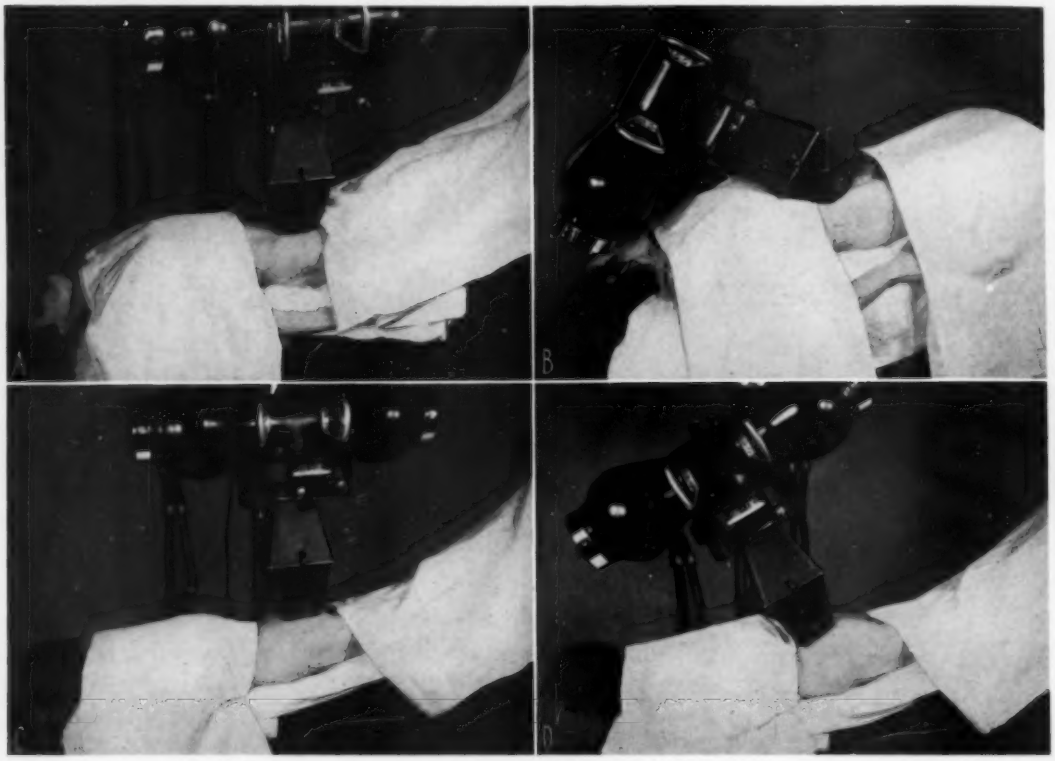

FIG. 4. Positions of patient for various portals: *A*, anterior lower portal, 15×15 cm., directed straight into pelvis; *B*, anterior upper portal, 10×10 cm., directed downward along axis of pelvis with compression; *C*, posterior lower portals, 15×15 cm. or 10×10 cm., directed straight inward; *D*, posterior upper portals, 10×10 cm., directed somewhat downward into parametrial region.

laterally. Anteriorly on either side the lower portals should be located with their lower edges just below the upper margin of the symphysis pubis and the roentgen-ray beam should be directed perpendicularly straight through into the pelvis; the upper portals should be marked out just above, and in this case the roentgen-ray beam should be projected obliquely downward along the pelvic axis. This is the portal in which deep compression may be most effectually used (Fig. 7). A bakelite cap made of material not more than 2 mm. thick may be fitted over the cone to more effectually permit compression. Posteriorly four fields, two on either side, should be laid out also, 10×10 cm., or 15×15 cm., depending on the size of the patient; in this case the lower fields will be at the same level as the corresponding anterior fields, with the lower edges just below the level of the coccyx, with the roentgen-ray beam directed perpendicularly inward. The second set of fields just above these should have the roentgen-ray beam projected downward toward the adnexal region.

Projection of a roentgen-ray beam along the pelvic axis with a patient in the prone position requires direct exposure of the vulva and this should be avoided. In all external irradiation the vulva is protected

by a bag containing equal parts of fuller's earth and china clay, held firmly between the thighs. Lateral fields exposed on either side will add materially to the dosage delivered to the parametrium.

5. *Accurately Locate the Portals and Determine the Optimum Direction of the Roentgen-Ray Beam in Each Case.* The lower anterior and posterior fields are centered directly over the parametrium so that in these cases the beam should be directed perpendicular to the body. The direction of the beams for the upper fields can be determined in the following manner (Fig. 5): A small adjustable indicator rod consisting of a straight piece of steel wire about 4 inches long attached to a pliable metal base (a piece of 1/16 inch sheet lead) is applied to the abdomen with adhesive or made sufficiently large that it will remain in place by its own weight, the base of the rod centered at the middle of the medial margin of the portal. With the index finger of one hand in the vaginal fornix lateral to the cervix, sight mentally along the rod, varying the angle of the rod until it is directed toward the vaginal finger (Fig. 6). This angle may be measured with relation to the table top by a protractor, and the direction of the beam for each portal can be determined in this manner for all subsequent treatments. This is an

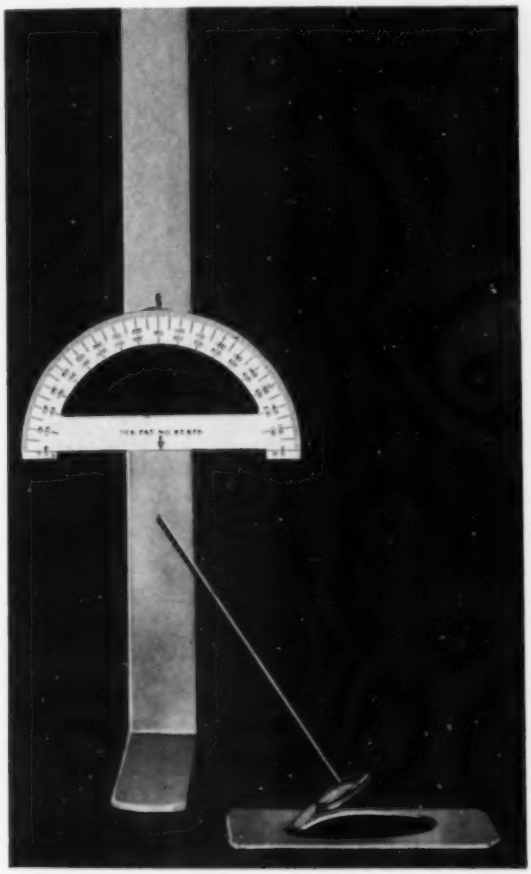

Fig. 5. Instrument used to determine proper angle for projection of roentgen-ray beam into parametrial region. A variable indicator rod fastened to a piece of lead is used to direct the angle of projection of the roentgen-ray beam. A protractor mounted upon a measuring stick is used to determine the angle in degrees.

Fig. 6. Measurement of angle necessary to project roentgen-ray beam into parametrial region. Place indicator rod in middle of medial border of portal. With one finger in vaginal fornix on same side sight mentally along indicator rod varying its direction until the line of sight projected into pelvis coincides with vaginal finger. Read off the angle on an adjustable protractor.

old method utilized by Holzknecht to determine the direction of the roentgen-ray beams for multiple portals in cross firing a tumor in the depth. It is sufficiently accurate for all practical purposes; indeed, extremely accurate cross firing may be

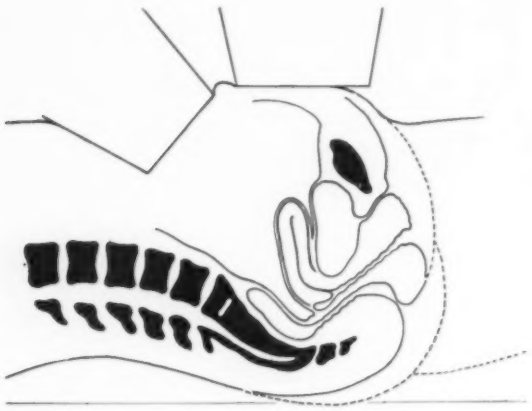

FIG. 7. Lateral view showing compression of anterior upper portal to project the roentgen-ray beam along the pelvic axis, and its relationship to the lower anterior portal. Care must be taken to avoid a point of excessive exposure where the two beams cross beneath the anterior abdominal wall.

undesirable since it may lead to too abrupt limitation of the field of irradiation.

6. *In setting up these portals for radiation therapy, due advantage should be taken of compression* wherever possible. Even slight compression materially increases the depth dose (Fig. 7).

7. *Dosage Factors.* We have utilized both 50 and 80 cm. distances, the latter in heavier patients because of the greater depth dose which it affords. With 200 kv., 18 ma., 1 mm. copper effective and 1 mm. aluminum filter, half-value layer of 1.46 Cu, 49 r per minute is delivered until a dose of 200 r, measured in air, is administered to all four anterior areas, and one lateral portal on a single day; the following day treatment is given through all four posterior portals and the other lateral portal. In this way both adnexal regions receive daily irradiation whereas each skin portal receives irradiation on alternate days only. This is continued until a pronounced skin reaction occurs; this usually progresses to desquamation. This was found to require about 2,000 r for a 15×15 cm. portal and 2,400 r for a 10×10 cm. portal.

8. *Cervical and vaginal irradiation with an intracavity cone* can be carried out during the same period, using 200 kv., 1 mm. copper effective and 1 mm. aluminum filter, 50 cm. distance, giving 1,000 r, measured in air, with a 3 cm. cylindrical *metal cone* (Fig. 8), daily for ten to fifteen days, depending upon the character of the growth, if no subsequent radium treatments are to be used. Large bulky tumors will

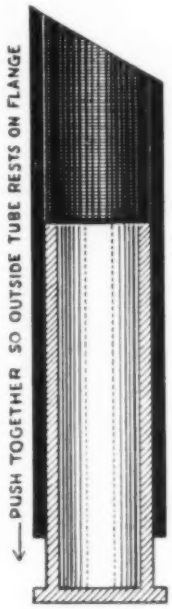

FIG. 8. Diagram showing suggested use of double cavity cones for vaginal irradiation. A cylindrical Fergusson hard rubber cone holds the vagina open exposing the cervix. The metal treatment cone about 2 to 3 cm. shorter than the hard rubber cone nests easily inside of the hard rubber cone insuring proper centering. This arrangement provides adequate irradiation of the proximal portion of the vagina as well as the cervix.

stand 1,500 r, whereas less bulky, necrotic ulcerating carcinomas require less radiation. For at least one-half of this dosage the radiation should be administered through a shorter metal tube which fits inside a hard rubber cylindrical speculum of the Fergusson type similar to that used

by Merritt,[4] not so much to secure spread of the beam into the parametrium as to secure irradiation of the proximal third of the vagina—a very essential feature in our experience to prevent growth along the vaginal wall. If no hard rubber cone is available, withdraw the metal cone about 1½ inches to properly irradiate the proximal portion of the vagina.

9. *Direct Alternate Treatments into the Right and Left Sides by Angulating the Intravaginal Cone as Much as Possible.* We have found it possible to angulate the tube as much as 15 to 17 degrees from the midline into each vaginal fornix. This should add materially to the radiation delivered to the adjacent adnexal regions.

10. *General Care of the Patient during Treatment.* It is especially necessary to keep the colon empty; this can best be accomplished by use of cleansing enemas, but a cathartic may be necessary at times. If any nausea is experienced, the cause must be determined at once. This naturally indicates that the intestines are not satisfactorily displaced and are receiving irradiation. This may be due to too little air remaining in the abdomen with insufficient tilting of patient to displace the intestines out of the pelvis or it may be due to collection of fecal material. A refill with air or a cathartic may be necessary to correct this condition.

MEASUREMENTS

For the purpose of this study 4 patients were selected, all clinical Stage III; one thin, height 5 ft., weight 90 lb., abdominal thickness at level of cervix with compression, 15 cm.; a second nearer average, height 5 ft. 8 in., weight 110 lb., abdominal thickness 16 cm.; a third stouter, height 5 ft. 4 in., weight 135 lb., abdominal thickness 19 cm., and a fourth obese, height 5 ft. 3 in., weight 193 lb., abdominal thickness 20.5 cm. with pendulous portion of abdomen retracted.

An integrating Victoreen intensimeter and a dosimeter were used for the measurements, both surface and intravaginal; the administration of radiation was supervised by the radiological residents in charge of radiation therapy at the St. Louis City Hospital, Drs. Chas. Nolan and H. L. Townsend, and the measurements were made by our physicist, Mr. Tracey Hinkley.

The roentgen-ray output was maintained by an iometer roentgen-ray constancy indicator, and the output at 18 ma. was delivered at 49 r per minute. Measurements were made for full duration of treatment. Both entrance and exit doses were measured with backscattering. The portals in which compression was used had a bakelite cap over the cone 2 mm. thick.

It was found that for the 15×15 portals, 200 r, measured in air, developed an average 255 r with backscattering about 30 r less than ordinarily found without pneumoperitoneum (285 r). This would indicate that an increase of about 12 per cent to the daily skin dose per portal would be permissible, or an increase of even more than this amount in the total dose delivered to each field over a period of weeks, if the original plan of 200 r, measured in air, delivered to each field was adhered to. Ordinarily in our experience without pneumoperitoneum, 1,400 r in air delivered, 200 r daily, to two anterior and two posterior portals will produce a desquamating reaction. With pneumoperitoneum this dosage did not result in nearly as severe a reaction. The delivery of 2,000 r to 15×15 cm. portals, and 2,400 r to 10×10 cm. portals resulted in desquamating reaction which seemed to us similar to those seen with 1,400 to 1,600 r without pneumoperitoneum where large fields were used.

Intravaginal measurements made with the ionization chamber in the lateral fornices indicated that, for the lower 15×15 cm. anterior portals, 160 r could be delivered into the parametrial regions in the thin individual and 100 r in the case of the stouter individual; for the lower 15×15 cm. posterior portals as much as 120 r could be delivered into the fornix of the thin individual, whereas in the case of the

stouter individual only 50 r could be delivered. For the upper 10×10 cm. anterior portals directed 50 degrees downward along the axis of the pelvis with maximum compression, as much as 140 r could be delivered into the fornix whereas, for the stouter individual, 120 r was the maximum amount which could be delivered. The relatively greater dose with the stouter individual was probably due to greater compressibility of the abdomen for the anterior upper portals. Posterior portals directed forward and upward along the pelvic axis were tried but found inadvisable since this practically constitutes a perineal portal which subjects the vulva to too severe reaction; likewise, the funnel-shaped character of the pelvis causes heavy bony structures to be superimposed upon the parametrial regions thereby reducing the amount of effective radiation which could reach the parametrium from these portals.

We have chosen instead an upper 10×10 cm. or 15×15 cm. posterior portal, directed somewhat downward, to converge on the parametrial region. With these portals 120 r could be delivered into the fornix in the thin person, but not more than 50 r could be delivered in the stouter individual, about the same as the lower posterior portals (see Table 1).

TABLE I

APPROXIMATE DOSAGE FROM EXTERNAL PELVIC IRRADIATION AS MEASURED IN VAGINAL FORNIX WITH ARTIFICIAL PNEUMOPERITONEUM WITH PATIENT IN TRENDELENBURG POSITION

			1. Thin Patient			2. Nearer Average Patient			3. Stout Patient			4. Obese Patient		
Portal	Size cm.	r in air portal	Plus backscatter	Vaginal dose	Vaginal dose Per cent	Plus backscatter	Vaginal dose	Vaginal dose Per cent	Plus backscatter	Vaginal dose	Vaginal dose Per cent	Plus backscatter	Vaginal dose	Vaginal dose Per cent
Anterior lower	15 × 15	200	260	160 r	63	260	175 r	67	265	100 r	39	300	90 r	30
Anterior upper	10 × 10	200	240	140 r	59	242	140 r	58	255	120 r	47	290	55 r*	19
Posterior lower	15 × 15	200	265	120 r	46	275	55 r*	20	280	50 r*	18	335*	104 r	31
Posterior upper	10 × 10 15 × 15	200	260	120 r	45	250	95 r*	38	280	50 r*	18	320	46 r*	14
Lateral	10 × 15	200	275	60 r	21	275	60 r	21	300	35 r*	12	320	25 r*	8
Total dose delivered for five portals of 200 r each, measured in air				600 r	234		525 r	204		355 r	134		230 r	102

* Owing to physical difficulties the measurements of radiation from some portals were not uniformly consistent.

The figures here recorded represent the maximum values attained. Comparison with other more accurate determinations made on water phantoms and cadavers would seem to indicate that radiation delivered into the pelvis from external sources is considerably greater by this method. This is especially true since these values do not take into account any additional irra-

diation which may be added from portals on the opposite side of the abdomen. The dosage values fall off very rapidly at the margins of the fields, so that slight variations of even a centimeter in the positioning of the portal, or even slight angulation of direction of the roentgen-ray beam may cause a falling off of dosage in the fornix as read on the ionization chamber from 140 r to 85 r or even less. The tilting of a large boggy uterus to one side was the probable explanation in one instance of a difference between 100 r and 65 r in dosage delivered to the two fornices by the beam directed along the pelvic axis. As a result, it was found advisable to place the inner margin of the upper anterior portals 1 to 2 cm. from the midline and incline the direction of the beam back about 10 degrees toward the midline, in addition to the approximately 60 degrees tilt along the axis of the pelvis.

INTRAVAGINAL IRRADIATION

Intravaginal irradiation can be carried out at the same time. The addition of pneumoperitoneum would not seem to produce as much variation in the dosage delivered in this case as in external irradiation since here the solid tissues to be irradiated intervene immediately beneath the portal of entry. The tumor-bearing cervix and the lower segment of the uterus being directly in the midline protect the rectum immediately posterior where the intravaginal beam is directed straight backward; angulation of the cone so as to direct the beam into either fornix likewise avoids the rectum. If the angulation of the beam is limited to a horizontal plane, then the bladder and rectum will also be protected. We have found it possible to angulate the vaginal cone 15 to 17 degrees laterally as suggested by Wasson, Bouslog and Jackson.[5] The removal of the small intestine from the field of irradiation by pneumoperitoneum permits larger doses, as previously mentioned: 800 to 1,000 r daily until 10,000* to 15,000 r* is given, using cones 2.5 to 3.5 cm. in diameter. The dosage varies greatly depending on the character and extent of the local

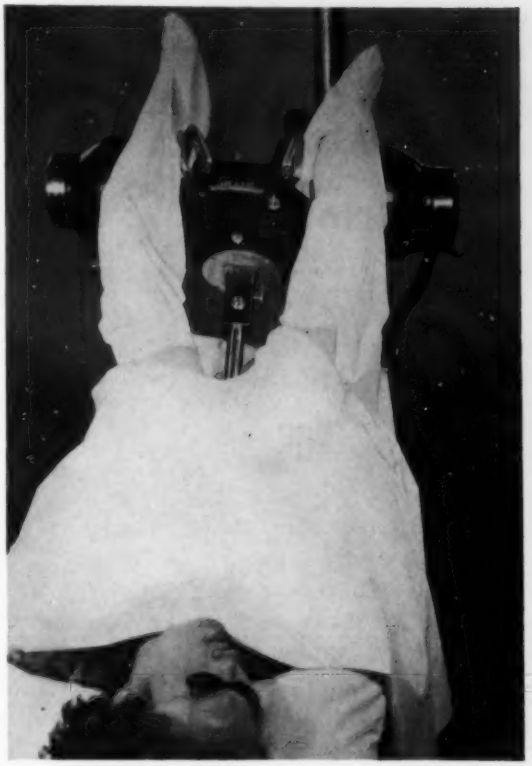

Fig. 9. Intravaginal irradiation with the patient in the Trendelenburg position.

growth; if the cervix is involved with a large bulky growth, total doses up to 15,000 r* or even more may be given; if the tumor is ulcerated and the amount of tissue smaller in quantity, then 10,000 r* is about the limit. A long metal cone (Odmann type) applied directly to the growth (Fig. 8) practically excludes the proximal portion of the vagina from irradiation; this is inadvisable for the entire course of irradiation since the proximal portion of the vagina should be irradiated to prevent spread along the vaginal septum. On this account it would seem advisable to utilize an accessory radiotransparent hard rubber or bakelite cylindrical speculum of the Fergusson type in a manner somewhat similar to that suggested by Merritt.[4] In place of having a short conical master cone attached to the

* Some tendency to rectal stricture coming on almost a year later would suggest proceeding cautiously. It is questionable if such large intravaginal doses are necessary; perhaps 75 per cent of the amouuts here indicated would suffice.

tube which makes a loose connection with the radiotransparent speculum (a few degrees variation in the angle of radiation might seriously overdose the proximal portion of the vagina) we suggest utilization of a metal cone which attaches tightly to the tube shield but slides readily into the hard rubber speculum. The metal tube should be 2.5 to 3 cm. shorter than the radiotransparent speculum so that when the two are nested properly there will still be 2.5 to 3 cm. of the proximal vagina subjected to irradiation. Since spread of the beam into the adjacent adnexal region is accomplished more effectively by angulation of the tube, this arrangement finds its greatest purpose in irradiation of the proximal third of the vagina. If a hard rubber speculum is used entirely, overexposure of the proximal portion of the vagina will preclude adequate irradiation of the cervical portions. Pneumoperitoneum would not seem to aid greatly the radiation dosage from this source so that perhaps the isodose charts reported by Erskine[6] for small fields of this character may be accepted as approximately correct—at least it would not seem that the dosage is reduced from use of pneumoperitoneum.

RESULTS

This procedure has been carried out in relatively few instances; only patients refusing radium therapy have been utilized. For a proper evaluation of the effectiveness of this method in cure of the disease, the treatment of many patients and observation over a long period of time will be necessary. More than 600 cases of carcinoma of the cervix treated with radium and roentgen therapy according to the methods prevailing at various periods over seventeen years have shown that our end-results in the total number of cases which we were able to follow are about the same as the prevailing average five-year cures reported throughout the country. There would be little point, therefore, in a statistical study of the percentage of cures. Such a group of cases, all treated and followed under the observation of the same individual should be a good background, however, for comparison of the reactions obtained by this and other methods of treatment. It may be permissible, therefore, to make some observations on the character of the reactions, both local and constitutional, obtained.

Although five portals besides an intravaginal treatment were given daily, nausea and vomiting did not occur if the intestines were properly displaced from the pelvis. To insure this the bowels must be kept empty and there must be sufficient air in the abdomen; in addition, the patient must be placed in a sufficiently inverted position to insure displacement of the intestines out of the pelvis. Rectal tenesmus and diarrhea have never developed. It would hardly seem possible to deliver such a daily dose of radiation over such a long period of time without nausea and vomiting or diarrhea if the intestines were included in the fields of irradiation. Likewise, it seems to us that the local skin reaction for the same dosage of roentgen radiation, measured in air, is less than when the intestines with their contents occupy the pelvis; this will permit a certain amount of additional radiation to each portal to build up to the same skin reaction, delivering, therefore, a greater quantity in the pelvis.

Perhaps the greatest variation in local reaction is noted in the cervix and vagina; with radium application in the cervix, and vaginal application either in a colpostat, vaginal pack or bomb, the greatest degree of reaction is naturally about the cervical orifice. Here the reaction is necrotic in character but rapidly shades off into a hemorrhagic denudation of the mucous membrane at the periphery of the cervix; the vaginal discharge is often profuse. With intravaginal roentgen irradiation the cervix does not show necrotic reaction, but becomes covered with a milky pseudomembrane which bleeds easily on manipulation, the epithelite reaction commonly seen on irradiation of mucous membranes elsewhere, and there is relatively less discharge. There seems to be even greater difference in the

vaginal reaction. With radium application the vaginal mucosa seems to show more reaction with relatively greater tendency to adhesive vaginitis, and the perivaginal fibrosis is most pronounced causing constriction of the vagina which may at times amount almost to obliteration. The reaction to intravaginal roentgen irradiation, on the other hand, does not seem to be as great on the vaginal mucosa; the reaction is attended by a certain degree of vaginal tenesmus manifested on digital examination and on attempting to separate the blades of a bivalve speculum for examination. This is not due to fibrous tissue contraction since even at this time the cylindrical speculum can be readily introduced So far, in our limited experience with intravaginal roentgen irradiation we have not seen the extreme degree of constriction attended with radium application. During the period of reaction, however, there may be increased sensitiveness of the parts. There is little difference in the reaction from intravaginal roentgen irradiation with pneumoperitoneum.

COMMENT

This method is suggested merely with the hope that it may be a means by which greater quantities of radiation may be delivered into the parametrial tissues in treatment of cancer of the cervix without permanent damage to other normal structures. We are not sure, of course, that the selection of fields for roentgen irradiation is the best and indeed it may be found that those commonly in use at present may be most practical. More accurate comparative measurements made by our physicists and the proof of clinical results will be necessary to ultimately determine these facts. The parametrial structures occupy regions scarcely 5 cm. in greatest diameter on either side of the pelvis; they bear the lymph nodes most frequently involved in the spread of the malignant process; with the vulnerable intestinal structures out of the way, why should not these areas be attacked by multiple portals and cross fire methods just the same as any other centrally located growth?

SUMMARY

The radiosensitivity of the intestines has always been a disadvantage in irradiation of the parametrial regions in cancer of the cervix.

Artificial pneumoperitoneum and the Trendelenburg position will permit almost complete displacement of intestinal structures from the pelvis.

A method of external roentgen irradiation directed to cross firing of adnexal regions under these conditions is described.

Vaginal measurements, in our limited experience, would seem to indicate that greater irradiation of the adenexal regions can be obtained by use of pneumoperitoneum and the Trendelenburg position than by ordinary external irradiation.

Constitutional reactions, even with five external and one vaginal portal daily, have failed to develop if the intestines are properly displaced and excluded from irradiation.*

REFERENCES

1. Pack, G. T., and Livingston, E. M., Editors. Treatment of Cancer and Allied Diseases. Paul B. Hoeber, Inc., New York, 1941.
2. Sante, L. R. A simplified pneumoperitoneum technique. Am. J. Roentgenol. & Rad. Therapy, 1922, *9*, 618–622.
3. Arneson, A. N., and Quimby, E. H. Distribution of roentgen radiation within the average female pelvis for different physical factors of irradiation. *Radiology*, 1935, *25*, 182–197.
4. Merritt, E. A. Roentgen therapy of cancer in the buccal cavity and of the cervix uteri. Am. J. Roentgenol. & Rad. Therapy, 1939, *42*, 418–422.
5. Wasson, W. W., Bouslog, J. S., and Jackson, A. P. Intra-orificial roentgen therapy. *Radiology*, 1940, *35*, 676–679.
6. Erskine, A. W. Expanding speculum for transvaginal roentgen therapy. Am. J. Roentgenol. & Rad. Therapy, 1939, *42*, 423–427.

* For discussion see page 706.

INTERSTITIAL IRRADIATION IN CANCER OF THE UTERINE CERVIX*

By J. ROBERT ANDREWS, M.D.
CLEVELAND, OHIO

IMPROVEMENT in the results obtained in the treatment of carcinoma of the uterine cervix is to be expected only if the proportion of early to late cases increases or if improvements in the techniques of treatment can be effected. Improvement of radiation techniques implies the administration of an increased dose of penetrating radiations to cancer affected or cancer bearing zones without compromising the integrity of normal tissues. Frazell[2] has shown that improvement in results occurs as the dose of radiation at the lateral pelvic walls increases. An increased dose to the outlying zones of involvement is probably not to be expected from changes in either the technique of external irradiation or the technique of intracavitary irradiation from improvements already well known, unless it should be effected by changes in the time and intensity factors, for in these techniques the tolerance of normal tissues is the dose limiting factor. Increased dosage must therefore be effected by interstitial irradiation. Such irradiation cannot haphazardly be either prescribed, administered or assessed. It must first be known what the common sites of lymph node involvement in the pelvis are. It must next be known what dose of radiation is received at these sites by methods of external and intracavitary irradiation commonly employed. Lastly, the order of magnitude of the deficiency of that dose, so far as a cancericidal dose is concerned, must be determined, for the amount by which that dose is deficient will therefore be the dose which must be administered by interstitial irradiation.

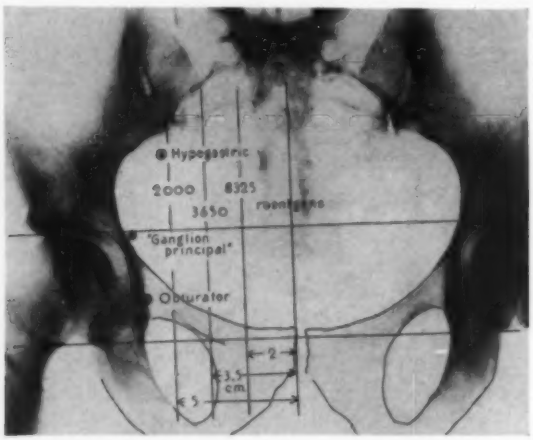

FIG. 1. Roentgenogram of normal female pelvis showing: locations of pelvic nodes (along with more centrally located ureteric nodes) most frequently involved by carcinoma metastatic from carcinoma of the uterine cervix; distance of these nodes from midline; mean values of the doses delivered by various methods of intracavitary and intravaginal irradiation at different distances from the midline (see Table 1).

The pelvic nodes usually involved by carcinoma secondary to carcinoma of the uterine cervix are well known. Taussig,[9] on the basis of his own experience, and Walker,[12] in an elaborate review of the literature of this subject, found that lymph node involvement was predominantly unilateral and that the nodes most likely to be affected were the hypogastric, at the bifurcations of the common iliac vessels, the ureteric, at the crossings of the uterine arteries and ureters, the obturator, at the entrances to the obturator canals and a node on either side at the lateral pelvic wall lying midway between the first and third, termed by Leveuf and Godard (quoted by Walker) the "ganglion principal." The roentgenogram is employed extensively in the determination of the positions of these nodes and in the prescription, administration and assessment of dosage in interstitial irradiation. The usual locations of the lateral (hypogastric, obturator, and "principal") nodes in respect to the bony struc-

* Read at the Twenty-sixth Annual Meeting, American Radium Society, Cleveland, Ohio, June 2-3, 1941.

tures seen on the roentgenogram are shown in Figure 1.

Arneson,[1] Wasserburger and Smereker,[13] Sandler,[6] Tod and Meredith[10] and Hurdon[3] have published data on the doses delivered to various points in the female pelvis by different techniques of intracavitary and intravaginal irradiation. The doses delivered to these same points by the paracervical methods of intracavitary, intravaginal and paracervical interstitial irradiation referred to above. These doses are charted on the roentgenogram in Figure 1. It is seen that all of the lateral pelvic nodes lie at, or near, the 2,000 r_γ zone but that none of them lie within this zone in regions of greater dosage.

The usual dose received by the hypogastric, "principal" and obturator lymph nodes from intracavitary, intravaginal and paracervical interstitial irradiation is therefore 2,000 r_γ. A minimum dose of 6,000 r_γ is probably required to destroy squamous cell carcinoma metastatic to lymph nodes with a dose of 8,000 r_γ probably being uniformly effective and yet within the bounds of normal tissue tolerance. A cancericidal

TABLE I

Dosage delivered by various techniques to different points in the pelvic contents and pelvic wall as determined by various authors.

Orientation of points:

Point A: Level of internal os 2 cm. from midline (lateral peritoneal surface of uterus).

Point B: Point in broad ligament 3.5 cm. from midline.

Point C: Fleshy pelvic wall and dose at obturator node and "ganglion principal," about 5 cm. lateral to midline.

Author	Dose (r_γ)		
	Point A	Point B	Point C
Arneson[1] intrauterine tandem and colpostat	12,000	7,000	3,000
Wasserburger and Smereker[13] Paris technique		2,300	1,230
Stockholm technique		2,000	900
Sandler[6] Marie Curie Hospital technique		3,000	1,600
Paris technique		4,500	2,250
Manchester technique		7,000	4,250
Tod and Meredith[10] Paris technique	6,150		2,500
Stockholm technique	5,400		1,800
Manchester technique	7,200		2,400
Walker[12] "4 cylinder" applicator	10,000	4,200	2,020
"3 cylinder" applicator	9,450	3,600	1,770
Hurdon[3]	6,600		3,000
Pitts and Waterman[5]			
Dose assessment on basis of Stenstrom, *et al.*[8] tables		1,500	1,000
Dose assessment on basis of Paterson and Parker[4] curves		3,700	2,350

Attention should be called to the fact that these calculations generally represent the maximum dosage under ideal conditions. For average conditions it probably is valid to take the mean values of the above determinations. These mean values are as follows:

Mean values	8,325	3,650	2,020

These values are probably a fair representation of the average dose in the average radium treatment of an average case of carcinoma of the uterine cervix.

interstitial irradiation technique of Pitts and Waterman[5] have been estimated by reference to standard dose tables. All of these data are summarized in Table I. As a working basis for average techniques it probably is valid to take the mean doses of all of these authors and arbitrarily establish these as the doses likely to be received in the pelvic nodes described above from the

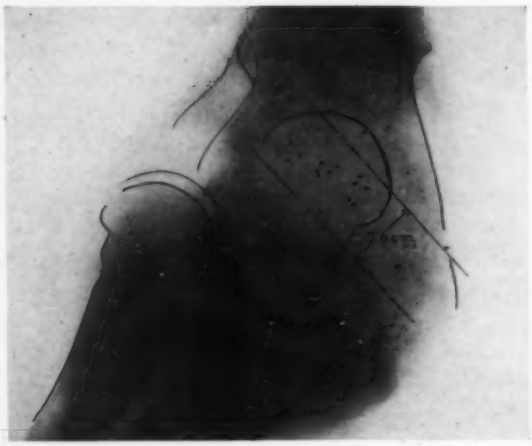

FIG. 2. Lateral roentgenogram of female pelvis after implantation of radon sources showing that the disposition of sources can be limited by transvaginal implantation to a slab of tissue less than 3 cm. thick.

dose in these nodes is deficient, therefore, by at least 4,000 r_{γ}, using the methods enumerated above, and this deficiency is the dose which must be provided by interstitial methods of irradiation. (The complementary effect of external roentgen irradiation on this dose is not considered in this study. Suffice it to say that such complementary irradiation might raise the total dose in these nodes from 6,000 to about 8,000 r_{γ}.)

Permanent gold radon implants, each containing 2 millicuries, have been employed in this study in preference to removable radium needles for it is thought that the technique of implantation is easier and because the necessity for removing the sources and the possibility of losing the sources in the pelvis are obviated. It is not thought that better distribution of sources can be achieved by the use of needles. The actual implantation of the radon implants is a blind transvaginal procedure subject only to the control of the palpating fingers and roentgenographic surveys made during the procedure. That the plane of implantation, and therefore the volume, can be fairly well controlled is shown in Figure 2, which is a lateral view of the pelvis made after the completion of the implantation which shows that the implants are concentrated in a slab of tissue the thickness of which is only 2.8 cm.

The actual technique of prescription of dosage and distribution of sources, the implantation of the sources, and the final assessment of dosage are as follows:

An anteroposterior roentgenogram of the pelvis is made and on this the positions of the hypogastric, "principal" and obturator nodes are spotted (Fig. 3). (The centrally located implants already shown on this film are some which were implanted superficially into surface vaginal extension of the tumor ten days before for the purpose of bringing, along with external roentgen irradiation, rather profuse bleeding under control before proceeding with the deep interstitial implantation. These sources are not considered in the calculations which follow.) The hypogastric node lies just below the sacroiliac joint, the obturator at the lateral pelvic wall one-third of the distance from a line joining Shenton's lines to a line joining the uppermost margins of the femoral heads and the "ganglion principal" at the lateral pelvic wall midway between these two (Walker[12]). The volume of a continuous zone of tissue lying between and including these nodes and a reasonable zone medially to allow for variations in implantation and positions of the nodes and to

FIG. 3. Roentgenogram of female pelvis (case of carcinoma of the uterine cervix) showing positions of frequently involved pelvic nodes spotted preparatory to determining dosage requirements.

bring this implanted zone within the range of adequate irradiation from other intracavitary or intravaginal sources must be computed. The thickness of this zone, if it is considered as a slab and if it is not palpably enlarged by grossly demonstrable tumor, does not exceed 2 cm., and the area can be determined by several methods, possibly the simplest being by treating the area as a series of thin cylinders as shown in Figure 4. This total area is first determined and the volume can then be determined by multiplying this by its thickness (2 cm.). The volume as determined in this instance is 42 cc. for a slab of tissue 2 cm. thick, and 62 cc. for a slab 3 cm. thick.

The dose, in millicurie-hours, required to deliver the required dose to this volume of tissue (5,000 r_γ in this instance was selected as being desirable) is determined with the aid of either the tables of Stenstrom, Quimby and Pendergrass[8] or the curves of Paterson and Parker.[4] For a volume of 42 cc. (thickness of slab, 2 cm.), 2,600 mc-hr., and for a volume of 62 cc. (thickness of slab, 3 cm.), 3,400 mc-hr. is required. The larger volume was selected as being more appropriate for this case as palpable pelvic tumor was present. Thirteen radon implants each containing 2 mc. therefore are required for a dose of 3,400 mc-hr.

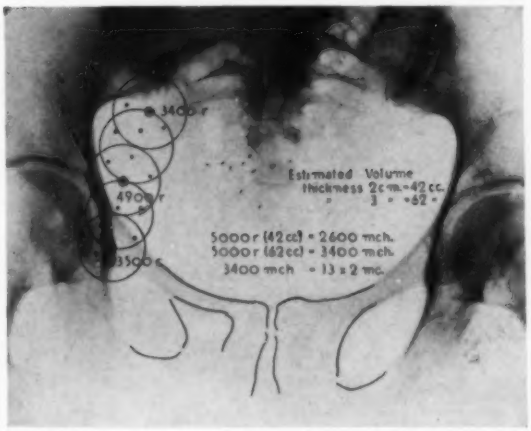

Fig. 4. Roentgenogram of female pelvis (case of carcinoma of the uterine cervix) showing: (*a*) circles drawn around points indicating lateral pelvic nodes to aid in the determination of the volume of this zone (for complete explanation see text); (*b*) estimated volume of this zone for thicknesses (in coronal, or near-coronal, plane) of 2 and 3 cm.; (*c*) amounts of radon required for doses of 5,000 r_γ to volumes of tissue noted (see text); (*d*) trial spotting of sources and trial determination of doses at points indicating nodes as determined by the Souttar method.

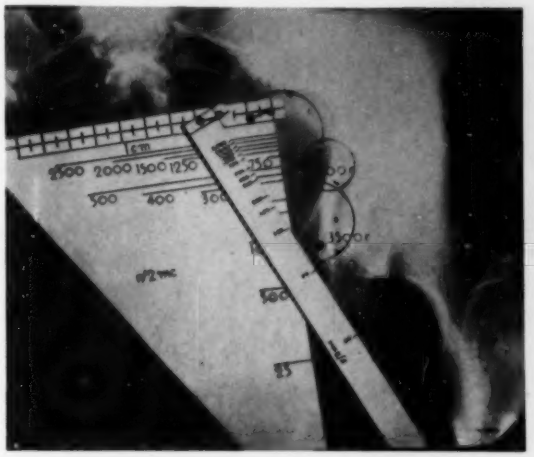

Fig. 5. Roentgenogram shown in Figure 4 with Souttar calculator superimposed. The right angle of the triangle lies on the point indicating the hypogastric node. The point of origin of the calculator bar lies on the 2 cm. mark. The side of the triangle lies on the point indicating one of the radon sources and where the calculator bar crosses this point the dose in gamma-ray roentgens at the node from this particular seed is read directly from the scale on the calculator bar.

The adequacy of this dose is determined by trial estimation of it by spotting in the thirteen sources on the roentgenogram. Distribution of these sources obviously cannot be optimum. It is considered, however, that the maximum distance which any of these sources will be separated, in the coronal or near-coronal plane, from these nodes will be 2 cm., for it has been shown (Fig. 2) that the thickness of the slab of implantation can be limited clinically to within 3 cm. All of the determinations are therefore based upon the proposition that the sources are at a maximum distance of 2 cm. in the coronal plane from the nodes and that if determinations of the doses are made on this basis the results will indicate minimum and not maximum doses. The dose delivered to each of the three nodes from each

FIG. 6. Roentgenogram of same case of carcinoma of the uterine cervix made during the implantation of radon sources. Distribution of sources in the regions of the hypogastric and obturator nodes is good but is deficient in the region of the "ganglion principal."

of the thirteen sources is rapidly determined by using the triangulation method of Souttar[7] with the calculator bar set at the 2 cm. level on the base of the triangle and the right angle of the triangle on the point designated as the site of the lymph node (Fig. 5). The perpendicular edge of the triangle is placed on the mark designating one of the implants and at the point where the edge of the calculator bar crosses this mark, the dose is read directly in gamma-ray roentgens from the calculator bar. The base of the triangle is marked in half centimeter divisions corrected for the magnification caused by the distortion of projection inherent in roentgenograms. The dose scale is also corrected for this magnification and is calibrated to read gamma-ray roentgens directly for each 2 millicuries-destroyed and filtered by 0.3 mm. of gold. The dosage rate under such conditions and used for the calibration of the dose scale was computed to be 9.2 r_γ/mch/cm. The results of the trial assessments of dosage are shown in Figure 4. The dose is still deficient by some 30 per cent from that determined above as being desirable. Sixteen or seventeen 2 mc. implants would therefore be used for the actual implantation instead of the thirteen as determined above.

The implantation can conveniently be performed on a combination cystoscopic and roentgenographic table. Half, or somewhat more, of the seeds are implanted transvaginally, under manual control, into the deep and lateral tissues of the pelvis and a roentgenogram is taken. The remainder of the implants are placed where needed. Such a preliminary film is shown in Figure 6. In this instance the initial distribution in the vicinity of both the hypogastric and obturator nodes is adequate, but no implants are present in the tissues intervening between the two. The remaining implants are then placed in this zone as shown in Figure 7.

The adequacy of the procedure is further checked by a final roentgenogram (Fig. 7) on which the doses delivered to the sites of the nodes are quickly determined by using again the Souttar calculator. It should be emphasized that the doses so determined are likely to be minimum and not maximum ones. Doses of 4,300 r_γ are shown at the hypogastric and obturator nodes and a

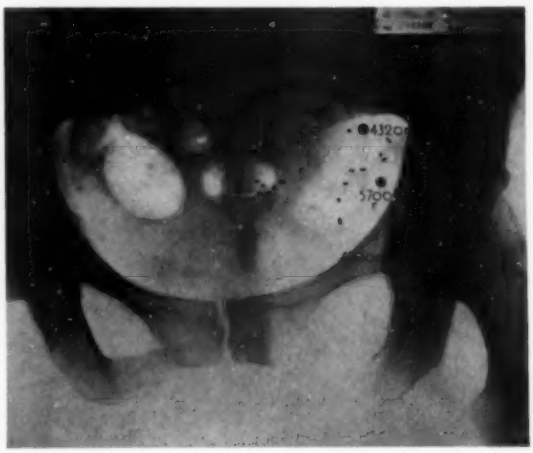

FIG. 7. Roentgenogram of same case of carcinoma of the uterine cervix made at the completion of the implantation of radon sources showing that three seeds have been placed in the vicinity of the "ganglion principal" and showing the dose in gamma-ray roentgens, as determined with the Souttar calculator, received at each of the three principal lateral pelvic lymph nodes.

dose of 5,700 r_γ is shown at the "ganglion principal." If 2,000 r_γ, this being the probable dose from the intracavitary irradiation, is added to these doses, then total doses of 6,300 r_γ at the hypogastric and obturator nodes and a total dose of 7,700 r_γ at the "ganglion principal" are obtained. These are well within the range of cancericidal doses.

The number of cases in which this technique has been employed, either in whole or in part, in the past two years is fourteen. These have been Stage III or late Stage II, parametrium, cases. No fatality, pelvic abscess, or hemorrhage has been observed. It has been our feeling that rectal reactions of the types described by Todd[11] may have been more severe than we have seen in those patients that have not had interstitial irradiation, but on the other hand a Stage I case in whom rectal bleeding was the most profound of any we have observed, had neither external roentgen irradiation nor interstitial gamma irradiation. Colostomy has not been necessary as even one acute complete obstruction was relieved after symptomatic treatment. Attempts have been made to determine anatomically the actual distribution of sources implanted blindly through the vaginal mucous membrane by performing the procedure on cadavers. The rigor of the cadaver precludes accurate control of the inserters and this part of the study was not considered very valid. The roentgenogram frequently shows that fewer seeds are present than were actually implanted. Some possibly are lost or fail to remain in the tissues and are withdrawn with the implanter. We have thought that some may enter and be lost in the rectum.

That the use of the method in the treatment of late Stage II, parametrium, and Stage III cases is justified is shown by the fact that Taussig reports that in 35 per cent of all Stage II cases involved pelvic nodes are already present. Carcinoma of the uterine cervix in either one of these two stages constitutes the chief indication for the employment of interstitial irradiation in the treatment of the lymph node metastases of the disease.

CONCLUSIONS

The dose of radiation delivered to lateral pelvic nodes in the usual intracavitary or intravaginal radium treatment of carcinoma of the uterine cervix is short of being a cancericidal one by at least 4,000 r_γ.

This deficiency can be obviated by treating the lymph node zones by interstitial irradiation.

Such interstitial irradiation can safely and successfully be performed by transvaginal implantation of permanent implants under manual and roentgenographic control and the adequacy of the dose can be graphically determined.

The high incidence of involved pelvic nodes in Stage II, parametrium, cases indicates the necessity for the complementary use of interstitial irradiation in the treatment of patients in this stage, and in Stage III.

The author wishes to express his appreciation to the Tumor Clinic of St. Vincent Charity Hospital for the use of some of the clinical material upon which this study is based.

REFERENCES

1. Arneson, A. N. Distribution of radiation within the average female pelvis for different methods of applying radium to the cervix. *Radiology*, 1936, *27*, 1–20.
2. Frazell, E. L. Correlation of calculated tumor doses and five-year survivals in radiation therapy of cancer of the cervix. Am. J. Roentgenol. & Rad. Therapy, 1938, *39*, 861–865.
3. Hurdon, E. Radium treatment of cancer of the uterus. Am. J. Roentgenol. & Rad. Therapy, 1941, *45*, 250–258.
4. Paterson, R., and Parker, H. M. Dosage system for interstitial radium therapy. *Brit. J. Radiol.*, 1938, *11*, 252; 313.
5. Pitts, H. C., and Waterman, G. B. Treatment of cancer of cervix uteri at the Rhode Island Hospital. *Surg., Gynec. & Obst.*, 1937, *64*, 30–38.
6. Sandler, B. An investigation into the dosage delivered by certain techniques in the radiation therapy of carcinoma cervix. *Brit. J. Radiol.*, 1938, *11*, 623–636.
7. Souttar, H. S. Radium dosage calculator. *Brit. J. Radiol.*, 1935, *8*, 385–392.

8. Stenstrom, W., Quimby, E. H., and Pendergrass, E. P. Report of the research and standardization committee of the American Radium Society. Am. J. Roentgenol. & Rad. Therapy, 1940, *43*, 118–125.
9. Taussig, F. J. Study of lymph glands in cancer of the cervix and cancer of the vulva. *Am. J. Obst. & Gynec.*, 1938, *36*, 819–832.
10. Tod, Margaret C., and Meredith, W. J. Dosage system for use in treatment of cancer of the uterine cervix. *Brit. J. Radiol.*, 1938, *11*, 809–823.
11. Todd, T. F. Rectal ulceration following irradiation treatment of carcinoma at the cervix uteri. *Surg., Gynec. & Obst.*, 1938, *67*, 617–631.
12. Walker, J. Z. New technique of treatment of carcinoma of the cervix uteri by combining x-ray and radium. *Brit. J. Radiol.*, 1940, *13*, 1–24.
13. Wasserburger, K., and Smereker, H. Radium treatment of carcinoma of the cervix uteri; investigation of dose distribution and special questions of treatment. *Strahlentherapie*, 1938, *62*, 584–600.

DISCUSSION ON PAPERS OF DRS. FRICKE AND BOWING, SANTE, AND ANDREWS

Dr. William P. Healy, New York City. Dr. Fricke's paper in general verifies well-known facts which have been common knowledge now for ten years. In going over the references to the literature, I was interested to note that he has, as a radiologist, looked only into radiological literature for his references. It is well known, it seems to me, that today possibly the most advanced work that has been done on cancer of the corpus uteri has come from the gynecologists who have been trained in irradiation, and if one wants to find modern literature on the treatment of cancer of the corpus and its classification he must read the journals in which the gynecologists' papers appear. I believe this applies just as well to the gynecologists; they should read the radiological journals. We should each know what the other group is doing.

Radiation therapists of course have been handicapped in their recognition of the radiosensitivity of adenocarcinoma to radiation methods of therapy because of the school of Regaud. Regaud stated some years ago that adenocarcinomas were not to be treated by irradiation. Therefore it should not be used; surgical methods were the only procedures to be followed.

Personally I was very glad to note that Dr. Fricke has recognized the value of histologic grading as a prognostic factor in cancers of the corpus. We have been talking about that for ten or twelve years, and there is no doubt about its value.

It has been emphasized at these meetings, and I think it ought to be a well-accepted fact today, that about 50 per cent of the cases of cancer of the corpus are of the low grade histologic type of cancer and represent the cases that are cured by a simple panhysterectomy.

The prognosis in histologic Grades 3 and 4, it is my impression, is not any better under surgery than it is under irradiation.

As Dr. Fricke said, radiation therapy has a very large field of usefulness in cancer of the corpus because of the advanced age of our patients, and the many contraindications to major surgery.

I believe that 6,400 to 7,400 millicurie-hours is rather a heavy dosage in these fragile uteri when given intrauterinely.

I would like to know, as a matter of information, how much roentgen radiation is ordinarily given and over what period of time and how soon it is started after the radium therapy is completed.

Dr. Lawrence A. Pomeroy, Cleveland, Ohio. I have been asked to discuss the paper by Dr. Sante on pneumoperitoneum during irradiation. As a matter of fact, I have had no personal experience in that method but a few things do occur to me.

It seems to me that this displacement of the intestines, from a mechanical point of view, is most excellent if you can really remove the intestines from the pelvis and be sure that there are no adhesions there to keep them from leaving the pelvis and going to the upper abdomen. The only shortcoming is that you can't remove the rectum from the pelvis temporarily, but I think the mechanical removal of the loops of small intestine is an excellent idea.

As I understand it, the skin dose, measured with backscatter, is reduced from 285 to 255 r per field. I wonder whether or not that is a significant change. It seems to me the greatest use of this method was not mentioned specifically and that is in the irradiation of carcinoma of the cervix developing in the stump after a supracervical hysterectomy. I think we all fear the presence of a loop of intestine adherent to the cervical stump in this group of cases. It seems to me that possibly the greatest promise of this method is in clearing the pelvis of the loops of intestine when treating the stump where there

is no uterine body to hold the intestines out of the way.

I have gone over this paper with much interest and it seems to me that further observation along this line will be very valuable.

Dr. Charles L. Martin, Dallas Texas. I feel that there are elements of danger in the blind type of implantation advocated by Dr. Andrews. The most serious complication seen with carcinoma of the cervix is ureteral stricture secondary to lateral extension of the tumor and therapy given to the sides of the pelvis should be aimed at preventing this serious condition. A series of experiments performed by Dr. Rogers and myself in 1926 revealed the fact that 75 milligram-hours applied directly to the ureter of a dog will produce a complete radiation stricture. It is evident, therefore, that implants placed near the ureters may produce the very condition that we wish to prevent.

Dr. Fred J. Taussig, St. Louis, Mo. I have employed this technique of interstitial irradiation with radon seeds in selected cases for many years. The immediate results are often very satisfactory but in the course of six months to one and a half years there is usually a reappearance and extension of the disease.

I have always taken a roentgenogram to be sure the radon seeds were placed in the desired position. This of course is a little bit clearer in the stereoroentgenograms.

I am still convinced that wherever technically possible, the surgical excision of a metastatic lymph node has definite advantages over the use of radon seeds.

Dr. Fricke (closing). I want to thank Dr. Healy for his very helpful discussion. We are always happy to learn from the gynecologist. We did not review the literature of the entire world on this subject. Since this is a radiologic society the subject is dealt with from the radiologic standpoint and the various surgical methods are not discussed in detail. Hence, the references used came from radiologic journals.

Dr. Healy brought up several points, one of which concerned the histologic grading of tumors. We have always realized the importance of that type of grading. In reviewing several hundred cases of carcinoma of the cervix, however, we could not find any difference in end-results among the cases in which the lesions were of Grades 2, 3 and 4 nor did we observe any real difference in the rate of five year cures. There were not enough carcinomas of Grade 1 to permit any conclusion to be drawn and although there were a significant number of those of Grade 2, they were in the minority.

Regarding the stage of disease, for many years we have used the classification presented. Doubtless this method is cumbersome but we believe it best to employ four stages in carcinoma of the uterine fundus, just as we do in carcinoma of the cervix. Briefly, in carcinoma of Stage I the growth is limited to the uterine cavity, the uterus is not enlarged and is freely movable. In Stage II there still is some degree of mobility but the uterus is definitely enlarged. In Stage III there is evident the beginning of fixation, frequently there is a small primary growth in the uterus, and malignant change is present in the cervix and in the vaginal walls. In Stage IV there is definite fixation, often a frozen pelvis and often obvious metastasis to other organs.

In regard to Dr. Healy's query about roentgen therapy, we first devote two or three weeks to radium therapy in each case, treating the patient about twice a week with intrauterine applications and daily with vaginal applications. At the end of this period roentgen therapy is carried out. This treatment consists of the application of about 550 roentgens, measured in air, to each of four or six portals, so that the treatment takes only four to six days after the conclusion of the radium therapy.

In this series of cases the five year results are better than in the series reported ten years ago because the surgeons, I believe, are beginning to have confidence in the efforts of the radiologists and are referring patients for radiation treatment earlier than formerly, that is in a less advanced stage of disease. In the group of ten years ago, there were only 23 per cent of five year survivals and of the entire group in only 21 per cent of the cases was the disease of Stage I or Stage II. Of the present group, in 40 per cent of the cases the disease was of Stage I or Stage II and in these cases of early carcinoma there were many patients with other serious diseases which precluded surgical intervention.

Dr. Sante (closing). Just a word with reference to Dr. Pomeroy's discussion. There can be no question of removal of the intestines from the pelvis by pneumoperitoneum because you can see very clearly under fluoroscopic examination that they are completely removed from the pelvis if enough air is introduced into the abdo-

men. The only thing that could possibly prevent them from being displaced would be adhesions which are relatively infrequent and rarely sufficient to prevent removal of the intestines.

One reason for the fields that were recommended by Arneson and Quimby was the division of the field anteriorly because in that way you do protect to some extent the midline structures of the bladder and rectum. It seems to me that by this method the rectum certainly would not receive any greater radiation than it would under ordinary conditions. Perhaps a little less because there would not be the additional scattering that would ordinarily come from the surrounding intestines.

Dr. Pomeroy did not understand my point with reference to the reduction of the skin surface dose after the removal of the underlying intestines with pneumoperitoneum. My idea was this—and it seemed the only explanation I could find—we noticed a lower ionization reading on the skin with pneumoperitoneum and then tried to think of why it should be. In a person with a relatively thin abdominal wall, if you have an underlying material which adds to the backscatter on the skin, you naturally get a greater surface dose with the ionization chamber on the skin than if the underlying material is removed. This was not claimed as any great advantage in the method except to indicate that it might permit one to give a little more primary dosage on the surface and thereby deliver a little greater dose in the depth.

Dr. Pomeroy's suggestion that its greatest usefulness might be in cases of cervical stump carcinoma is interesting. I hadn't thought of it particularly, yet I can see how it might be of value here. The only thing that suggests itself to me is that under these conditions there would be a greater likelihood of intestinal adhesions, the only thing which might make it impossible to carry out the method.

Vol. 46, No. 5

CLASSIFICATION OF CANCER OF THE BREAST

By SAMUEL GEORGE SCHENCK, M.D.
BROOKLYN, NEW YORK

WHEN a patient first presents herself with a growth in the breast and the diagnosis of carcinoma is established by biopsy, the case is classified in the proper clinical group and subdivision. The accurate allocation of each case to its proper category serves several purposes. It ensures a thorough physical examination which permits no omissions in the systematic survey of the patient, for the reason that the grouping takes into consideration every possible clinical finding. It also indicates the management of the case, groups the factors of operability and inoperability, and tends to estimate the immediate and ultimate prognosis. It clarifies the maze of statistical five year reports by indicating the type of case and the original condition of the lesion treated. Not only do the criteria for operability vary in different clinics and by different surgeons, so that the evaluation of published statistics on five year survivals is difficult and often confusing, but also the original degree of involvement of the disease at the time of the first examination is seldom described when presenting the statistical end-results from the treatment employed. Hence, the results obtained by different methods of therapy cannot be estimated properly when the exact status of the condition originally treated is unknown or inaccurately presented. This confused state is unnecessary and may be obviated by designating each case in the proper stage immediately after the diagnosis of cancer is confirmed. In this way, the therapeutic results may be evaluated readily for each group of cases so assembled in the classification.

The classification of breast cancer into clinical groups is not new. In 1905, Steinthal[8] first suggested a clinical classification upon which many of the recent ones are based. Pfahler,[5] Portmann[6] and the American College of Surgeons[3] have lately classified breast cancer into three or more clinical groups, roughly corresponding to early, intermediate and late stages of the disease. The objections to these groupings are probably best expressed by enumerating the postulates of a clinical classification. These dicta should comprise the following features: namely, all-inclusiveness, practicability, treatment, prognosis and statistical compilation.

A classification which is adequate for many types of cases, but which does not permit a definite designation for each possibility that may be presented fails to fulfill the first prerequisite of the postulates enumerated above. Furthermore, the classification must be serviceable and practical, or its value is considerably lessened. The value of the classification is in direct proportion to its practical application. Practicability includes serviceability; hence, the classification serves to include all types of cases generally met with, encourages thoroughness in the physical examination, points out the plan of treatment, indicates the possible outcome, and aids materially in the evaluation of end-results for each of the various types of cases classified.

Other classifications, formerly suggested, have failed not only to receive general recognition and acceptance, but also have not satisfied the postulates of a clinical grouping just described. In the classification about to be described, these prerequisites, in my opinion, have been satisfied, thereby assisting, to no small extent, in the study of the disease. It has proved serviceable in more than two hundred cases studied in the past two years.

Rather than first presenting the final classification table and from it explaining each of the stages, divisions, and subdivisions, it is deemed advisable to start from the beginning with the birth and then the evolution of the classification, so that a clearer and more precise understanding of the development of this clinical grouping

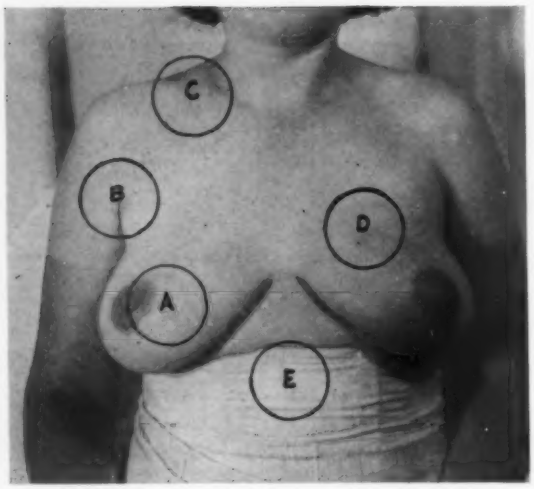

FIG. 1. The five main divisions of the classification of cancer of the breast (A to E), each representing the physical findings obtained from examination. A represents the status of the primary new-growth in the affected breast; B, the findings in the adjacent axilla; C, in the supraclavicular fossa; D, in the contralateral breast and its axilla and supraclavicular area; and E, distant metastasis to the chest, bone and other parts.

can be grasped. By so doing the final chart becomes at once understandable and easily remembered. In a recent communication,[7] the groundwork was laid from which the present chart was evolved. Although the classification, viewed as a unit, is by no means simple, once the evolution of the grouping is understood, the rationale of the entire table and its component parts becomes apparent.

PHYSICAL EXAMINATION

The complete physical examination includes careful inspection and palpation of (1) the affected breast, (2) the adjacent axilla and arm, (3) the supraclavicular fossa, (4) the contralateral breast including its axillary and supraclavicular area, and (5) the rest of the body including the chest, bones and other organs.

In the affected breast, the tumor is accurately measured and its mobility in relation to the overlying skin and to the underlying tissues is noted. The skin, including the nipple, is carefully inspected and palpated, observing its color and texture, the presence of nodules, ulceration or discharge. When the examination of the entire breast is completed, the examiner next passes to the axilla, which is investigated for the presence of nodes. Their number, size, fixity and the condition of the overlying skin are recorded in systematic order. The presence or absence of lymphedema of the upper extremity is noted. Then the supraclavicular fossa is thoroughly examined for possible involvement. The examination proceeds to the contralateral breast and its regional glands for the possibility of extension. The breast, subcutaneous tissue and skin are carefully examined and the adjacent axillary and supraclavicular regions are also palpated for possible metastasis. Lastly, the physical examination is completed by a thorough examination of the chest, skeletal system, liver and other organs, with the assistance of roentgenography, if necessary.

BIRTH OF THE CLASSIFICATION

After the biopsy report indicates that we are dealing with cancer of the breast, the patient is then classified according to the following plan. If the physical status of the malignant breast itself is designated by capital A, the findings in the adjacent axilla by B, in the supraclavicular fossa by C, in the contralateral breast and its regional lymph glands by D, and in the rest of the organs (distant metastasis) by E, we have the five large groups of the classification (Fig. 1), paralleling in sequence the routine physical examination. The designation A, which stands for the findings in the involved breast, is further subdivided into three subgroups indicated by the arabic numerals, 1, 2 and 3. Arabic numeral 1 designates the size of the widest diameter of the new-growth carefully obtained on physical examination. The status of the skin of the breast is represented by arabic number 2 which is further subdivided into five smaller divisions which accurately place the patient in the proper category which represents the clinical observations

of the skin at the first examination. Hence, 2a indicates that the skin is involved in the malignant process by revealing an edematous or indurated appearance, or by presenting the so-called pig-skin or orange-peel skin. Further, 2b means that one or more nodules are present in the skin of the breast. Subdivision 2c is represented by the so-called inflammatory cancer in which the skin assumes an inflamed or erysipelas-like appearance. When the tumor shows evidence of having ulcerated into the skin, the patient is placed in class 2d. Cancer *en cuirasse* is designated by 2e. The arabic numeral 3 is reserved for those neoplasms that are definitely adherent to the underlying pectoral muscles and fascia.

In brief, therefore, remembering that A represents the findings of the primary disease in the breast (Fig. 2), A1 indicates the size of the growth; A2, the fixity of the growth to the skin, and A3, its adherence to the underlying tissues. If, in addition to being firmly adherent to the skin, the tumor also involves the tegumen further, A2 is further subdivided into a, b, c, d and e, depending on the nature of the involvement. Therefore, the designation is A2a when the skin is indurated or edematous, A2b when skin nodes are present, A2c when the skin is inflamed, A2d when it is ulcerated and A2e when the designation is cancer *en cuirasse*.

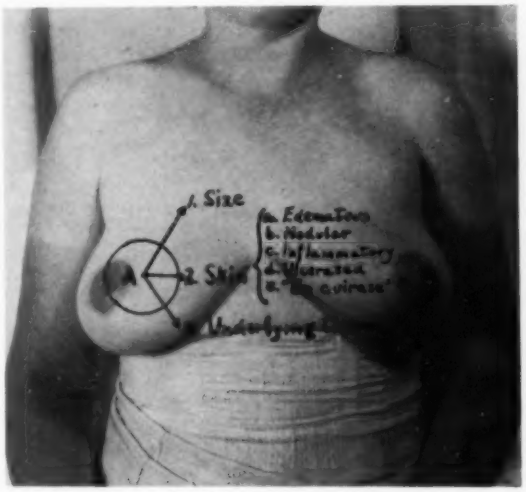

Fig. 2. The findings in the affected breast (A) are represented by three divisions: 1, the size of the tumor measured in its longest diameter; 2, the status of the skin adherent to the underlying growth; 3, the fixity of the neoplasm to the underlying tissues (chest wall). The findings in the skin of the breast (2) are further subdivided: a, the skin is partially or wholly indurated or edematous (including the orange-peel or pig-skin breast); b, the presence of one or more nodules in the skin; c, an inflamed skin (the so-called inflammatory cancer); d, an ulcerated skin (ulcerated cancer); e, cancer *en cuirasse* (the armor-plate cancer of the breast).

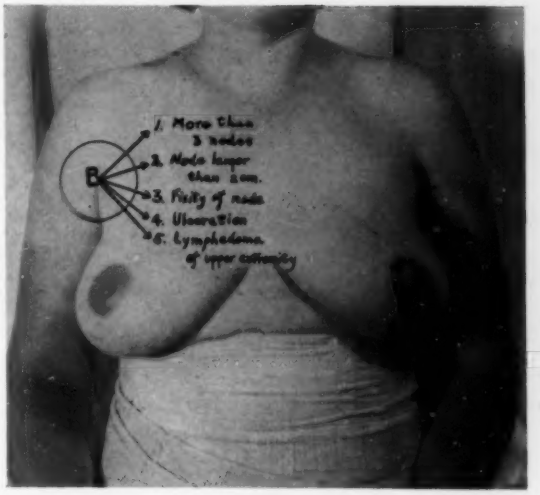

Fig. 3. The findings in the axilla (B) are indicated by five subdivisions: 1, the presence of more than three nodes, each movable and measuring less than 2 cm. in its widest diameter; 2, one or more nodes larger than 2 cm. in size; 3, the fixity of one or more nodes, regardless of their size; 4, the ulceration of a node; 5, lymphedema of the upper extremity (in the absence of a previous mastectomy or of irradiation).

As in the physical examination of the patient, attention is next drawn to the neighboring axilla which is represented by the capital letter B. This group (Fig. 3) is further subdivided into five lesser divisions depending on the possible clinical findings. When more than three nodes are palpable, the designation is B1, provided each node measures less than 2 cm. in its widest diameter and is freely movable. If one or more nodes measure more than 2 cm. in diameter, representing a rather large axillary metastatic nodule, the designation be-

Fig. 4. The presence of one or more supraclavicular nodes is represented by C.

comes B2. If one or more nodes, regardless of size, are firmly adherent to the skin or underlying structures or both, the classification becomes B3. Should a node ulcerate into the skin, the case is relegated to B4. If the upper extremity shows evidence of lymphedema in the absence of a previous operation or radiation therapy, the designation becomes B5.

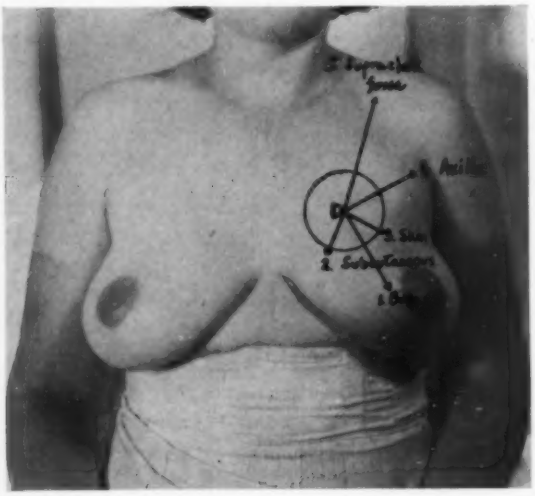

Fig. 5. The findings in the opposite breast and regional glands, represented by D, are divided into: 1, an intramammary tumor; 2, a subcutaneous mass; 3, cutaneous nodules; 4, axillary nodes, and 5, supraclavicular involvement of that side.

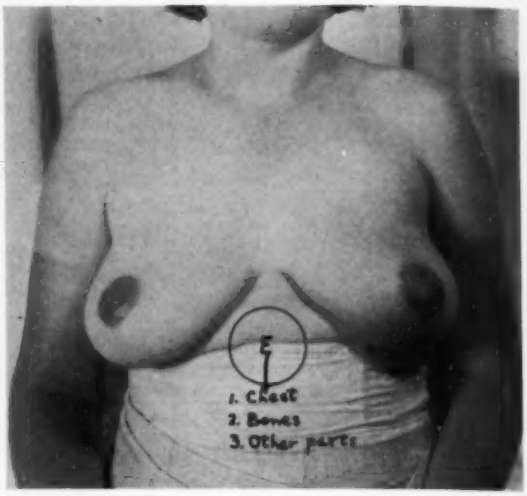

Fig. 6. Distant metastases, indicated by E, are further divided into three groups: 1, intrathoracic metastasis; 2, bone metastasis; 3, extension to other organs or parts.

The group designated by C is reserved for those patients who present clinical evidence of the disease with one or more supraclavicular nodes on the affected side (Fig. 4).

The status of the contralateral breast and its axilla and supraclavicular fossa is represented by D. This group is further divided into five distinct parts (Fig. 5). An intramammary tumor is designated as D1, a subcutaneous mass by D2, one or more

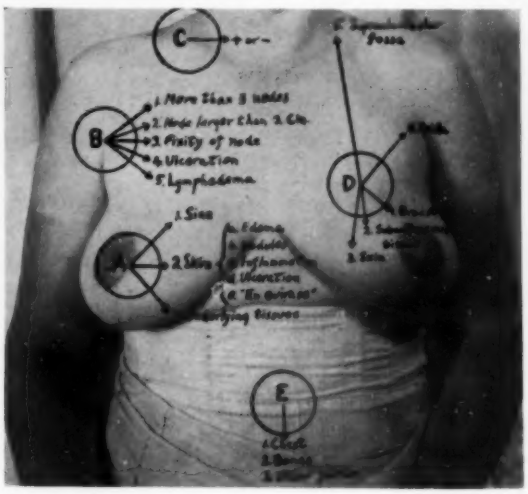

Fig. 7. Composite picture of clinical classification of breast cancer.

cutaneous nodules by D_3, palpable evidence of the disease in one or more axillary nodes as D_4 and involvement of the adjacent supraclavicular space by D_5.

Distant metastases are indicated by the letter E which may be conveniently subdivided in three further divisions (Fig. 6). Hence, E_1 stands for metastasis to the chest, E_2 to the skeletal system, and E_3 to other parts or organs.

The five main groups with their subdivisions may now be brought together into one composite picture (Fig. 7). This illustration indicates the proper designation of each case at a glance.

EVOLUTION OF THE CLASSIFICATION

It is generally recognized that there are, broadly speaking, three clinical types of breast cancer. The early or mild case with a small, freely movable tumor and no glandular involvement; the intermediate or farther advanced case with the tumor somewhat larger and/or with several small, freely movable axillary nodes, and the advanced type with a large growth which may be adherent or fixed and which may have considerable axillary involvement or supraclavicular extension, or which may show contralateral or distant metastasis. We divide breast cancer into three such clinical stages, adding a fourth which is reserved solely for those cases which first present themselves for treatment after they have been previously operated on. Stage I represents the early type; Stage II, the intermediate or more advanced form; and Stage III, the advanced cancer (Table 1). Arbitrarily, we take 3 and 6 cm. as the pivotal figures in reference to the transverse diameter of the growth in the breast to allocate the lesion to its proper stage. If the tumor measures less than 3 cm. in its widest diameter, it is considered to be a small lesion, an early involvement, provided it is movable in relation to the skin and underlying tissues and provided there is no evident extension to the axilla and supraclavicular fossa and no distant metastasis. Such a lesion is placed in Stage I.

If the growth measures from 3 to 6 cm. in diameter, the overlying skin is free and normal, and the tumor is not fixed to the underlying tissues, the case is put in Stage II, provided the axilla is free from disease or reveals no more than three movable nodes which are not fixed and which measure less than 2 cm. in diameter. To remain in this stage, the supraclavicular fossa and opposite breast and its lymph-draining areas must be free from disease and there must be no evidence of distant metastasis.

Table I

Stage I	Early cases
Stage II	Moderately advanced cases
Stage III	Advanced cases
Stage IV	Postoperative cases

Stage III is reserved for all the other cases which have not as yet been operated upon when first seen. Thus, if the tumor measures more than 6 cm. in diameter, it falls into this stage. When the growth is firmly adherent to the skin, regardless of its size, it becomes a Stage III case. Similarly, when the mass is fixed to the chest wall, the case is considered advanced and is classified in Stage III. Other manifestations which immediately relegate the patient to this group are edema of the breast, nodules in the skin, inflammatory carcinoma, ulceration of the tumor and cancer *en cuirasse*, all obviously late, advanced or highly malignant characteristics.

Stage III also includes patients who have more than three palpable axillary malignant nodes, or in whom one or more nodes measure more than 2 cm. in diameter, or in whom the nodes are fixed or ulcerated. Lymphedema of the upper extremity without previous mastectomy or irradiation is another indication for allocation in this stage. Regardless of the status in the breast and the axillary manifestations, the presence of a hard, clinically malignant supraclavicular nodule indicates an advanced case and rightfully belongs to Stage III. Similarly, contralateral extension and dis-

tant metastases are factors in designating the patient in Stage III.

Stage IV is reserved for patients who are first examined after having been previously operated upon elsewhere for the breast cancer. The nature of the previous operation is designated by the capital letter O followed by the arabic numerals 1, 2 and 3 depending on the type of surgery performed. Hence O1 represents a simple excision of the breast growth; O2, a simple mastectomy, and O3 a radical mastectomy. If, upon examination, there is no evidence of this disease, the patient is classified as Stage IV O1, or IV O2 or IV O3, depending upon the nature of the previous operation (Table II). If there is evidence of local recurrence, the same designation as for the affected breast in non-operated cases, namely A, is used to classify this condition. Local recurrence, A, is subdivided into: 1, which represents recurrence in the remaining breast tissue; 2, in the skin, scar, stitch holes, and 3, in the underlying chest wall. Regional recurrence is represented by B when there is involvement of the axilla and C when the disease has spread to the supraclavicular fossa. Metastasis to the contralateral breast and its nodes is represented by D which may be further subdivided into five component parts depending upon the location of the involvement. Hence, D1 indicates extension to the breast tissue itself; D2, to the subcutaneous tissue; D3, to the skin; D4, to the axilla, and D5

TABLE II

TYPE OF OPERATION (O)

Stage IV	O1	Simple excision of tumor
	O2	Simple mastectomy
	O3	Radical mastectomy

CHART I

CLINICAL CLASSIFICATION OF BREAST CANCER

Stage	A			B	C	D	E
	Primary Tumor			Axilla	Supra-clavicular Fossa	Opposite Breast and Regional Nodes	Distant Metastasis
	Size	Skin	Underlying Tissues				
I	Less than 3 cm.	—	—	—	—	—	—
II	3 to 6 cm.	—	—	1 to 3 small, movable nodes less than 2 cm. in diameter	—	—	—
III	1. More than 6 cm.	2. Firmly adherent a. Edematous or indurated (pig-skin) b. Skin nodes c. Inflamed (inflammatory cancer) d. Ulcerated e. cancer *en cuirasse*	3. Adherent	1. More than 3 nodes palpable 2. Node larger than 2 cm. 3. Fixity of node 4. Ulceration 5. Lymphedema of upper extremity	One or more nodes palpable	1. Intramammary tumor 2. Subcutaneous tumor 3. Cutaneous nodule 4. Palpable node in axilla 5. Palpable node in supraclavicular fossa	1. Chest 2. Bone 3. Other parts
IV	Type of Operation O1. Excision O2. Simple mastectomy O3. Radical mastectomy	Local Recurrence 1. In remaining breast tissue 2. In skin, scar, stitch holes 3. In underlying chest wall		Regional Recurrence In axilla	Regional Recurrence In supra-clavicular fossa	Metastasis to 1. Mamma 2. Subcutaneous tissue 3. Skin 4. Axilla 5. Supraclavicular fossa	1. To chest 2. To skeleton 3. To other parts

to the supraclavicular fossa. Distant metastasis, indicated by E, is further divided into: E1, which represents intrathoracic metastasis; E2, skeletal involvement; and E3, spread to other organs and parts. For example, a patient who has had a previous radical mastectomy and is first observed with liver metastasis is classified as Stage IV (O_3) E_3.

The four stages of the disease and their grouping into five regions designated by A to E, each representing the exact status of the disease in its various locations in which the findings are further subdivided from 1 to 5, and, in one instance, resubdivided from a to e, are gathered together and tabulated into one chart (Chart 1). From this chart, it is possible to relegate immediately each case to its proper place, after the examination is completed and once the development and evolution of the classification are understood.

APPLICATION OF THE CLASSIFICATION

Before attempting to apply the classification in a practical way, it should be understood that the designation given each case represents the farthest clinical advance of the disease. For example, the patient is classified in the C group if one or more malignant nodes are found in the supraclavicular space, regardless of the status in the axilla and in the affected breast. Similarly, the presence of metastasis in bone, at the time of the first examination (and confirmed roentgenologically), indicates the farthest outpost of the malignant condition. Therefore, regardless of the findings in A to D, the case is classified as Stage III E2, which is the designation for an advanced form of breast cancer which has metastasized to the skeletal system. Therefore, in arriving at the proper classification for each case, the farthest extension of the cancer is looked for (Fig. 8), passing in our mind from E to A, rather than going from A to E, which is the natural sequence in examining the case clinically. The absence of distant metastasis rules out E. The absence of contralateral extension excludes D, and so on to A. The tumor may measure less than 6 cm. in diameter and yet ulcerate the skin. The designation will

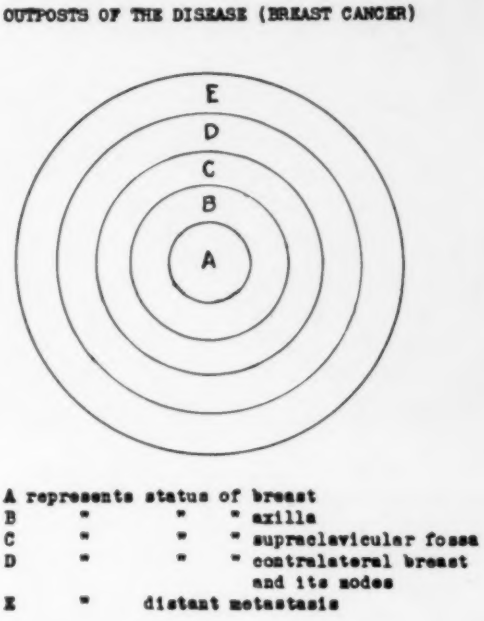

FIG. 8. Schematic drawing in which concentric circles represent the five divisions (A to E) of the classification, which indicate the extension of the growth to various parts. A stands for the status of the cancer in the breast itself; B, in the axilla; C, in the supraclavicular region; D, in the contralateral breast and its lymph nodes; and E represents distant metastasis. Each case is classified at the initial examination in the group or division which indicates the farthest advance or outpost of the disease. E, standing for distant metastasis, is the proper designation for lung, liver, bone, etc. metastases, regardless of the clinical findings in the breast, axilla, etc. (A to D). D, representing involvement of the opposite breast and/or its nodes, is the farthest extension of the disease, provided there are no distant metastases to the intrathoracic organs, bone and other parts. Hence, the case falls in the D group, regardless of the findings of the primary tumor of the breast, its axilla and its supraclavicular fossa. And so we pass from E to A in determining the farthest extension of the disease.

be Stage III A2d (Fig. 9), provided there is no involvement of the axilla, supraclavicular fossa, contralateral side and no distant metastasis. Given a case in which the primary growth measures less than 3

FIG. 9. Ulcerating carcinoma of right breast. No involvement of axilla, supraclavicular region, contralateral side, and no distant metastasis. The classification is therefore Stage III A2d.

cm. and a small, pea-sized, movable, malignant node is discovered in the axilla, the classification becomes Stage II B, which is the designation for axillary involvement of a primary tumor measuring no more than 6 cm. in diameter and presenting no more than 3 small, movable nodes in the axilla, each measuring less than 2 cm. in diameter.

Occasionally, it is necessary to change the classification of a patient after operative intervention. At the first examination, for example, there may not be any palpable nodes in the axilla. However, upon operation, the lymph nodes are shown to be involved. The designation is then changed from the A to the B group.

TREATMENT AND PROGNOSIS BASED ON THE CLASSIFICATION

All cases falling into Stages I and II should receive radical surgery and irradiation. Statistically, the outlook is good, especially in Stage I. Patients who are classified in Stage III and Stage IV (with recurrence) are primarily radiological problems, requiring high voltage irradiation or radium or both. Conservative surgery may not infrequently be indicated, particularly simple mastectomy, more with an aim of palliation rather than cure. These are the advanced cases, and the five year cure rates are low. However, much can be accomplished by intelligent palliation with irradiation, with or without conservative surgery, and an occasional patient may thus be cured.

Therefore, in reviewing the classification chart, the factors which indicate radical operability and inoperability can be readily enumerated. Stages I and II represent the operable group which presupposes that: 1, the primary growth is less than 6 cm. in diameter; 2, it is not firmly adherent to the skin; 3, it is not adherent to the chest wall; 4, no more than three movable nodes are present in the axilla, each measuring less than 2 cm. in diameter; 5, there are no supraclavicular nodes; 6, there is no extension to the opposite breast and its regional glands, and 7, there is no distant metastasis.

The factors which mitigate against radical operation may be enumerated from Stage III in the classification chart as follows: 1, a primary growth larger than 6 cm. in diameter; 2, a primary tumor firmly adherent to the skin which may have an edematous or indurated appearance, which may reveal the presence of nodules, which may be inflamed, ulcerated, or which may present the type sometimes described as cancer *en cuirasse;* 3, a primary tumor adherent to the chest wall; 4, axillary extension with more than three palpable nodes, a node measuring over 2 cm. in diameter, nodes fixed in the axilla or ulcerated, or lymphedema of the upper extremity; 5, supraclavicular involvement; 6, extension to the contralateral breast and/or its regional nodes; 7, distant metastasis.

We are cognizant of the fact that exception may be taken at least to two or three of the factors enumerated as contraindications to radical surgery. Reference is made to large malignant tumors of the breast, measuring more than 6 cm. in diameter and lesions adherent to the skin with or without

ulceration. It is well appreciated that other factors besides size and fixity play a vital rôle in determining the operability of the lesion. The grading of these tumors by Broders[1,2] and MacCarty[4] in which the degree of malignancy is determined microscopically is one factor to be considered. The tumor bed, the age of the patient, the general physical condition of the subject, the presence or absence of anemia, debilitating disease, arteriosclerosis, cardiac and nephritic complications, hypertension, acute and chronic pulmonary infections, as tuberculosis, etc., cannot be ignored. Many large growths are relatively more benign and show less tendency to spread regionally and metastasize to distant parts than some very small lesions, which are only discovered after a large axillary mass has been revealed or a metastatic focus has been found in the chest, bone or elsewhere. Similarly, small, scirrhous tumors, especially in the aged, are sometimes very slow growing, and are more apt to break down and ulcerate by blocking off their circulation than to spread to the regional glands, thus remaining localized to the breast for a long period of time.

Are these types of cases to be considered unsuitable for radical operation? We are inclined to believe so, although our mind is open until a sufficient number of five year statistical survival rates for these types of lesions is available. At present, such statistics are not readily obtainable because of the lack of allocating such cases to a definite group or class at the onset of treatment. Reports in the literature with five year end-results are numerous, but the status of the lesion at the initial visit is either not mentioned or discussed or is only given in a general way. By means of the classification herein presented, it is hoped to avoid such inaccuracies and omissions. The best type of treatment available can ultimately be outlined for each group of cases so classified.

It is believed that tumors larger than 6 cm. in diameter are well advanced and the case unsuitable for radical surgery. Even though the axilla may show no clinical involvement and the overlying skin not firmly attached to the growth, malignant cells are usually to be found choking the lymphatics to the skin and to the chest wall radiating in all directions from the primary lesion. We therefore feel that such a late lesion lies beyond the ability of the surgeon's knife to extirpate the entire disease. Therefore, radical mastectomy, we believe, would be a heroic procedure with more to lose than gain, and simple mastectomy, together with radiation therapy, may accomplish at least as much. Similarly, the ulcerating, slow growing, scirrhous type of lesion, frequently seen in the aged, is best managed with a minimum of surgery. The necrotic, foul, discharging mass may be removed in toto by a simple mastectomy or by a wide excision to be followed by radiation therapy or may be treated by radiotherapy alone. Radical surgery is not justified in these cases in which the life expectancy is short and the possibility for a cure remote.

By the same token, a mass firmly adherent to the chest wall (pectoral muscles and fascia) has already extended beyond the possibility of radical removal. In these cases tumor cells are already found in the intercostal lymphatics which cannot be surgically removed. Such cases are irradiation problems and should be treated expectantly with roentgen rays and radium, with or without less extensive procedures than radical mastectomy. It is generally agreed that the other factors of inoperability enumerated above mitigate against radical surgery.

EVALUATION OF END-RESULTS BASED ON THE CLASSIFICATION

It is evident that by this classification the evaluation of statistical reports will become relatively simple and significant. By designating each case in its proper category at the beginning and compiling five year survival rates for each of the groups noting the type of therapy given, considerable progress can be expected in the man-

agement of this dreaded malady. It will tend to clarify the muddled state that we are now in, evaluate more thoroughly and accurately the clinical features of the disease; test the efficacy of therapy, and evolve a more accurate prognosis. To fully carry out its purpose, however, it must be generally accepted so that the eventual statistics may be sufficiently abundant to draw the proper conclusions.

SUMMARY

A new clinical classification for carcinoma ot the breast is presented and explained.

In the past two years, I have so classified more than two hundred patients with cancer of the breast, and have found the classification both practical and serviceable. Inasmuch as this communication is in the nature of a preliminary report, complete data will be given concerning these cases in a subsequent article.

REFERENCES

1. BRODERS, A. C. Grading of carcinoma. *Minnesota Med.*, 1925, *8*, 726–730.
2. BRODERS, A. C. Carcinoma; grading and practical application. *Arch. Path. & Lab. Med.*, 1926 *2*, 376–381.
3. KRESS, L. C. Cancer of the breast; diagnostic methods and statistics on preoperative radiation. Presented before the Medical Society the of State of New York, April 25, 1939.
4. MACCARTY, W. C. Cytologic diagnosis of neoplasms. *J. Am. M. Ass.*, 1923, *81*, 519–522.
5. PFAHLER, G. E. Treatment of carcinoma of the breast. Caldwell Lecture, 1937. AM. J. ROENTGENOL. & RAD. THERAPY, 1938, *39*, 1–18.
6. PORTMANN, U. V. Irradiation in the treatment of cancer of the breast. *Cleveland Clin. Quart.*, 1939, *6*, 109–115.
7. SCHENCK, S. G. A clinical classification of cancer of the breast. *Surgery*, 1939, *5*, 567–571.
8. STEINTHAL, C. F. Zur Dauerheilung des Brustkrebses. *Beitr. z. klin. Chir.*, 1905, *47*, 226.

Vol. 46, No. 5

THE IMPORTANCE OF FIELD DISTRIBUTION MEASUREMENTS

By LILLIAN E. JACOBSON, *Physicist*
Radiotherapy Department, Montefiore Hospital
NEW YORK, NEW YORK

INTRODUCTION

THIS paper describes the variation in dosage rate from point to point on the surface and in successive planes inside of a pressed wood phantom. The surface dosage rate was investigated for different tubes with and without cones.

The average variation for a 30 cm. diameter field at 50 cm. focus-skin distance between the center and periphery is about 25 per cent for the most uniform fields, more variation on the anode side and less on the cathode side.

The greatest number of fields which I measured were far less uniform, some containing sharp cut offs, others marked decreases in dosage rate due to the tube being off center, the anode itself, the design of cones, the glass window retaining the oil, and built-in ionization chamber.

The field conditions which exist on each therapy outfit should be investigated and not taken for granted. The cause for the irregularity can then be located and in many cases remedied.

EXPERIMENTAL WORK

The conditions of irradiation for our equipment were a half-value layer of 1.32 mm. Cu and a dosage rate of 34 r per minute at 50 cm. focus-skin distance (200 kv., 25 ma., 0.5 mm. Cu and 1 mm. Al in addition to the inherent filtration).

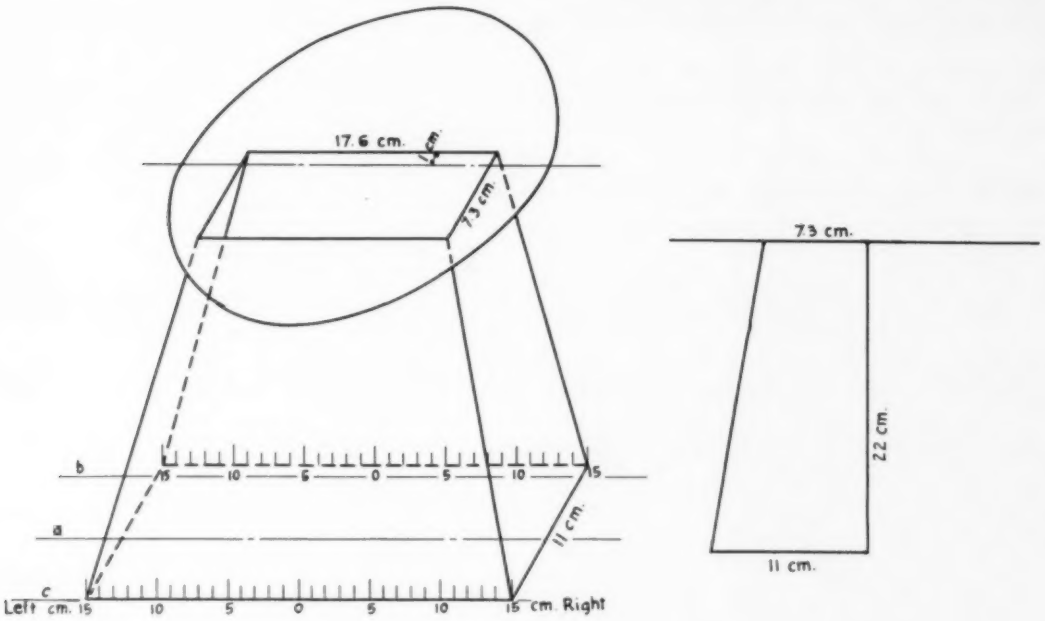

FIG 1. Cone for tangential irradiation.

Any cone could have been used without materially affecting the results. The cone (Fig. 1) which was used was designed originally by Finzi for tangential irradiation, which I started to investigate when diverted by a disturbing non-uniform field. One side is at the center of the field and the

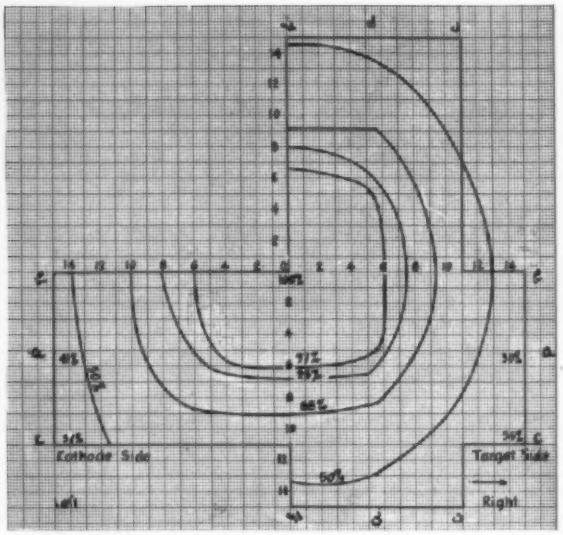

FIG. 2. Isodose curves measured in air for plane at 50 cm. focus-skin distance, half-value layer 1.32 mm. Cu.

opposite side is 11 cm. off center. The field is 30 cm. long by 11 cm. wide. The target skin distance is 50 cm.

To aid in placing the ionization chamber in reproducible positions, the cone was marked off as follows: a line was drawn lengthwise down the center of the cone and called the *a* line, the line along the center of the roentgen-ray field was called the *b* line, and the opposite edge was called the *c* line. The bottom of the cone was then marked off in centimeter divisions reading from 0 at the center to 15 cm. right or left. The right side is the anode side and the left the cathode side. The position of the ionization chamber can readily be specified by designating it by line and number. For example, c-12 means the chamber is on the *c* line 12 cm. to the right of center.

Measurements were made in air with a Victoreen condenser dosimeter when the cone was parallel and also when perpendicular to the long axis of the tube. Figure 2 shows isodose curves plotted from these measurements. In the center is a fairly uniform field whose diameter is 12 cm., the boundary of which has a dosage rate of 97 per cent. At greater distances from the center the isodose lines become more circular in shape. The 85 per cent curve encircles a field whose diameter is approximately 20 cm., the 50 per cent curve encircles a field whose diameter is approximately 28 cm. The isolated figures at the edge of the field show the percentage of the central beam received there. It will be noted that when the cone is parallel to the long axis of the tube, 30 per cent is received on the target side 14 cm. from the center along line *a*, while on the side opposite 41 per cent is received; along line *c* only 9.5 per cent is received on the target side and 31 per cent on the side opposite. When the cone is perpendicular 49 per cent is received along the

FIG. 4. Pinhole picture of target.

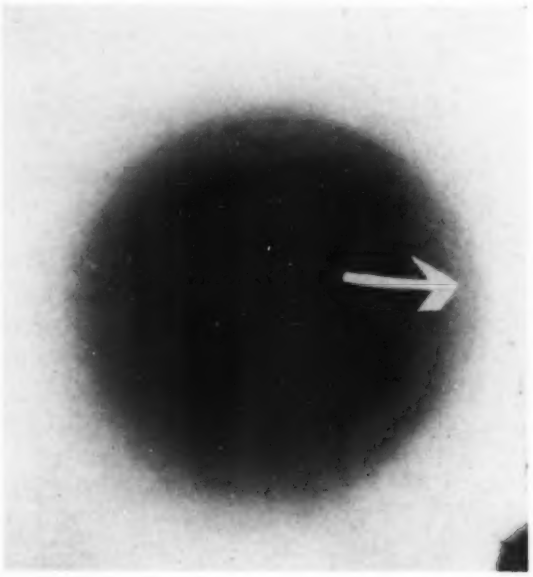

FIG. 3. Roentgenogram at 25 cm. focus-skin distance.

a line at 14 cm. from the center and 41 per cent on the opposite side. This is far from a uniform field.

Figure 3 is a roentgenogram of the field at 25 cm. focus-skin distance, taken without any cone. It was expected that the uniform portion would be 15 cm. but it is considerably less. The field appears as if made by three focal spots, for there seems to be an incomplete superposition of three shadows. The arrow points to the target side. The pinhole picture of the target shown in Figure 4 shows several distinct focal spots. The size of the focal spot is 9×14 mm. and this size should be considered in designing the upper opening of cones.

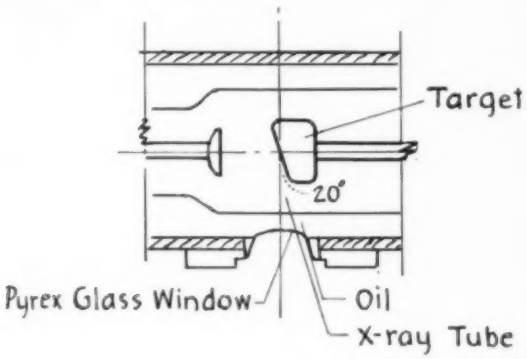

Fig. 5. Diagram of roentgen tube.

An attempt was made to find the cause of the irregular distribution. It was thought that the tube was off center, but this proved not to be the case. Allowing for the increase in distance according to the inverse square law, 92 per cent should be received at 15 cm. from the center on line *b* and 88 per cent on the outermost corner or 15 cm. along the *c* line. The target is 20° to the vertical plane. Because the peripheral rays on the target side come off at the small angle of approximately 4° to the face of the target, the decrease in intensity is about 12 per cent. This should leave 80 per cent instead of 30 per cent. Since the so-called "heel" effect does not exist on the opposite side where the rays emerge at an angle of 20° to the target face, the intensity there should be 88 per cent instead of 41 per cent.

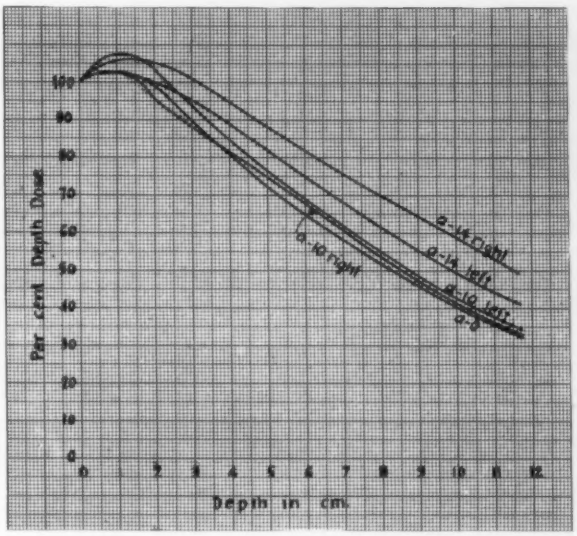

Fig. 6. Percentage of surface dose at different depths and different positions in plane perpendicular to long axis of tube.

The decrease was not due to the cone for similar figures were found without any cone.

Figure 5 is a schematic diagram of the tube in the tube head. It is oil cooled, oil

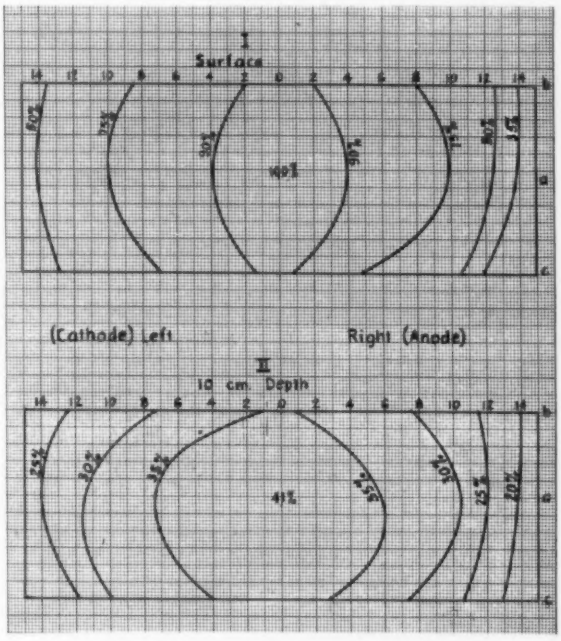

Fig. 7. Isodose curves (*I*) at the surface at 50 cm. focus-skin distance and (*II*) 10 cm. below the surface. Half-value layer 1.32 mm. Cu.

immersed. Note that the rays emerge through a concave pyrex glass window which encloses the oil. The rays emerging from the rim of this window are not cut off by any filtering device. The sharp decrease in dosage rate between 10 cm. and 14 cm. from the center, from 85 per cent to about 35 per cent, is most likely due to the rays going through the edge of the glass at a very small glancing angle thus traversing a thickness between 1 and 2 cm. of glass. If this is the case the peripheral rays should have greater penetration and this is shown by the curves in Figure 6 where the rays at 14 cm. from the center have the greatest percentage depth dose if the surface at the same distance is taken as 100 per cent.

Since such installations are being used, depth dosage measurements were made. A phantom made of masonite pressed wood was used. Fifteen centimeter thickness of boards was always used as the backscattering medium. The ionization chamber could be removed for measurement without disturbing the placement of the chamber boards thus allowing the re-insertion of the ionization chamber.

Isodose curves at the surface and the plane parallel to the surface at a depth of 10 cm. are shown in Figure 7. At the surface 90 per cent is received 4 cm. from the center of the cone. One edge received 50 per cent and the target edge received 35 per cent. This distribution with backscatter is more irregular than that without backscatter, as seen in Figure 2. Ten centimeters below the surface the central portion of about 12 cm. diameter is bounded by the 35 per cent isodose line. The target edge of the cone receives 20 per cent, almost as much as at the surface, and the opposite side 25 per cent. This field distribution is more uniform than at the surface.

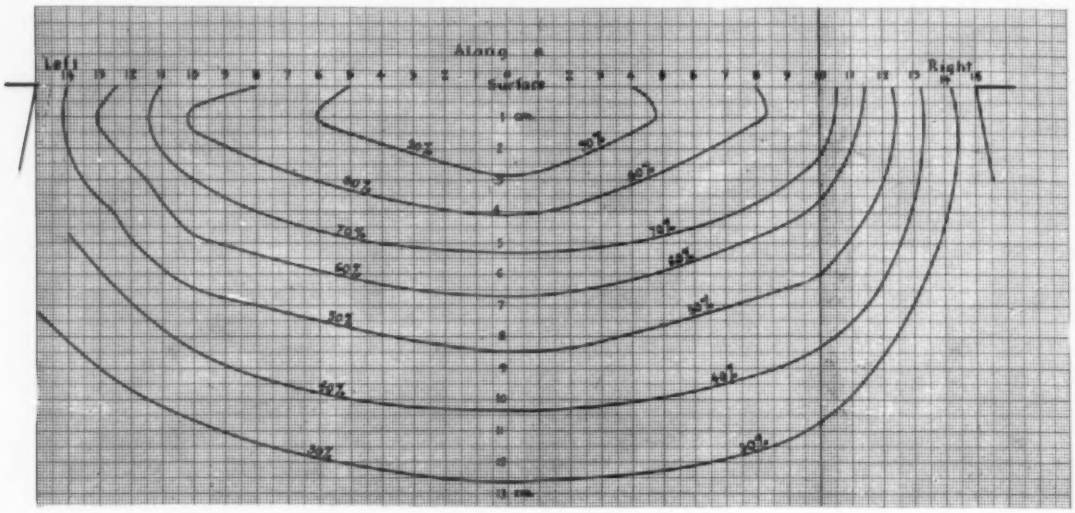

Fig. 8. Isodose curves in plane perpendicular to surface through center of cone (*a* line). Half-value layer 1.32 mm. Cu.

Figure 8 shows the isodose curves along the plane through the center of the cone or *a* line. At the middle, 41 per cent reaches a depth of 10 cm., at the target edge 19.5 per cent and at the opposite edge 25 per cent. On the target side the dosage rate for the first 4 cm. is approximately the same, 32 per cent. It increases over the surface value for the first 2 cm. after which it begins to decrease. This is caused by an increase in direct radiation at a depth which was cut off from that portion of the surface just above. The rays which strike at the depth have come through the central portion on the surface. The curve marked c-14 right in Figure 9 shows the increase in depth dosage for the periphery of the field. Until a

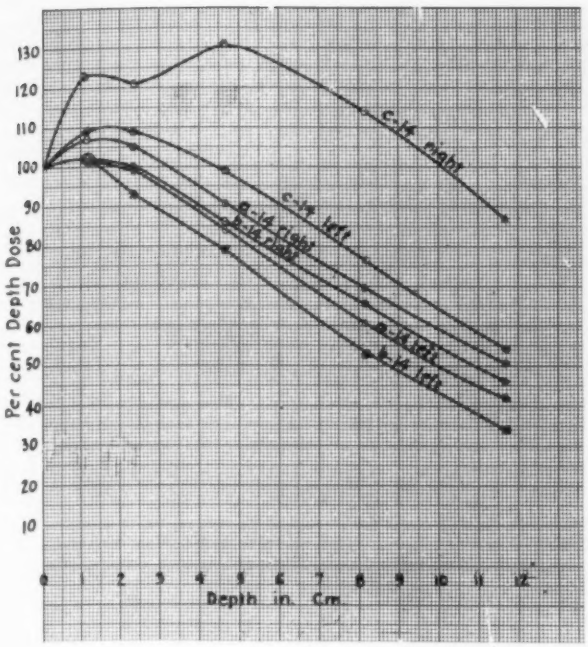

FIG. 9. Percentage of surface dose received at various depths in planes perpendicular to long axis of tube. (Surface at each position is called 100 per cent. Half-value layer 1.32 mm. Cu.)

depth of 10 cm. more radiation is received than at the corresponding point on the

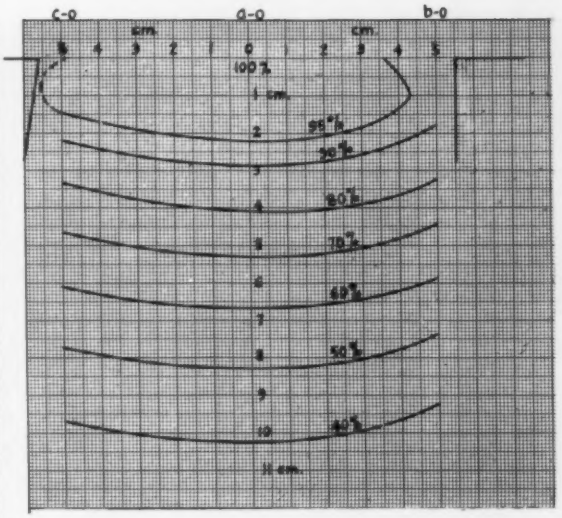

FIG. 10. Isodose curves in plane perpendicular to axis of tube at center or o line. Half-value layer 1.32 mm. Cu.

surface. For this set of curves each surface measurement is called 100 per cent. The dose below the surface is compared with that received at the corresponding position on the surface. On the c-14 right curve 131 per cent reaches a depth of 4.5 cm. Under controlled conditions such a depth dosage might be of practical value.

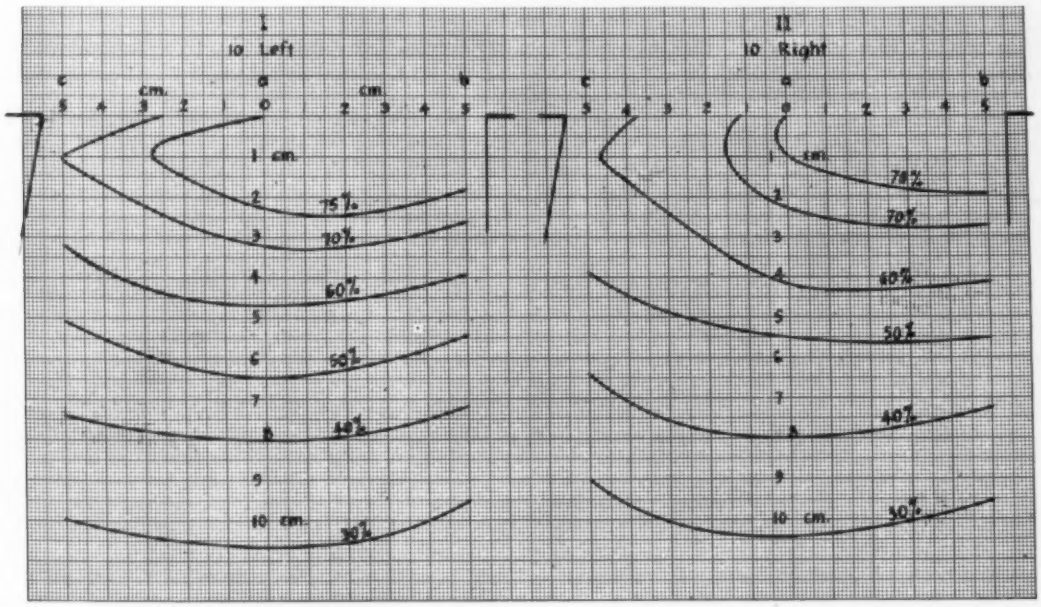

FIG. 11. Isodose curves in planes perpendicular to axis of tube (*I*) 10 cm. to left and (*II*) 10 cm. to right of center. Half-value layer 1.32 mm. Cu.

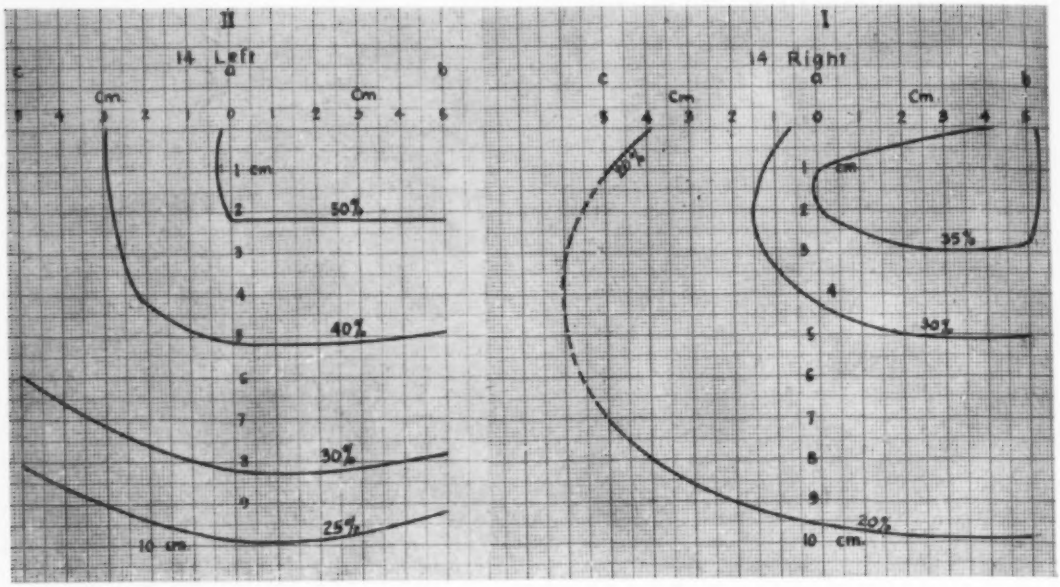

FIG. 12. Isodose curves in planes perpendicular to axis of tube (*I*) 14 cm. to right and (*II*) 14 cm. to left of center. Half-value layer 1.32 mm. Cu.

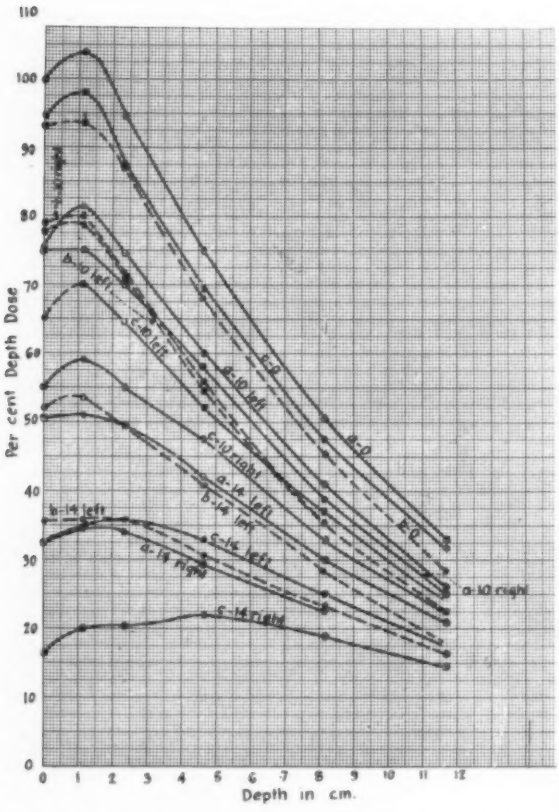

FIG. 13. Percentage of dosage rate at center a-o received at surface and various depths below for different positions. Half-value layer 1.32 mm. Cu.

The isodose curves perpendicular to the long axis of the tube along the center or o line are shown in Figure 10. They are rather flat and symmetrical except for the first few centimeters. Figure 11 shows two sets of curves, one taken along line *a* 10 cm. to the right of the center, the other 10 cm. to the left. The *b* and *c* sides are indicated. The curves here show more irregularity especially on the right side; 32 per cent reaches a depth of 10 cm. on the right side and 37 per cent on the left side. Figure 12 is the set of curves for the fields at 14 cm. to the right and left of the center line. These curves are quite irregular. On the right side, 19 per cent reaches a depth of 10 cm., on the left side 25 per cent. The upper portions are considerably different between the left and right sides.

A comparison for different depths at various positions in the field is best obtained from the curves in Figure 13. Here the amount received at a-o is called 100 per cent, and the others are compared to this. a-o was measured at the beginning and at the end of the measurements for each curve.

DISCUSSION

The manufacturers of the equipment which gave the preceding distribution stated that the field at 50 cm. focus-skin distance was 30 cm. in diameter. The tube had an excellent life and was used with the assumption that the field was fairly uniform. Most hospitals and radiotherapists have the same conception. I would suggest that the manufacturer or distributor should state definitely what the largest usable field is and how uniform or non-uniform it is, in addition to giving the purchaser the approximate dosage rate.

Yet this is not sufficient, for the cause of the non-uniformity is not always in the tube or tube head.

Other roentgen-ray machines were measured. A similar installation and tube gave approximately the same values for a 30×30 cm. field at 50 cm. focus-skin distance, 33 per cent at three corners and 8 per cent at the fourth corner. Another oil cooled, oil immersed tube in a different tube head with master cone containing a built-in ionization chamber or so-called intensimeter had about 35 per cent on the corners of a 20×20 cm. field. However, when the master cone was removed 73 per cent was obtained 15 cm. from the center on the target side and 83 per cent on the opposite side. The cause for the non-uniformity in this case was the ionization chamber. An oil cooled, air immersed tube gave approximately the same values. An air cooled tube with cone in place yielded the following values at the corners for a 20×20 cm. field, 3, 14, 25, and 35 per cent. This field is shown in Figure 14. The actual usable part is about 13×13 cm. instead of 20×20 cm. and is off center. Figure 15 shows a field which was used as a 15×15 cm. square field. In another installation the opening in the tube head allowed a larger field to be used than actually existed on the target side. Here the cut off was due to the target.

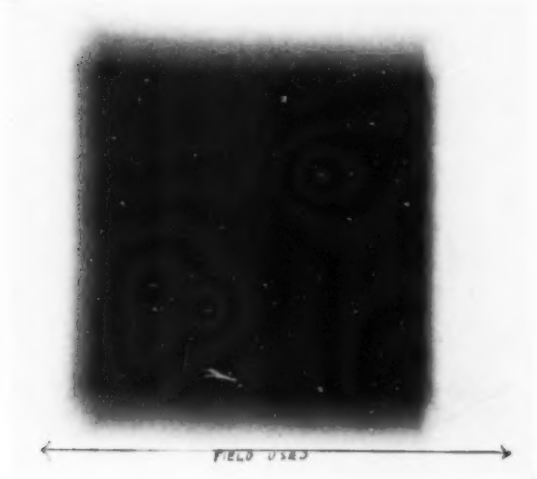

Fig. 14. Field of 20×20 cm. cone.

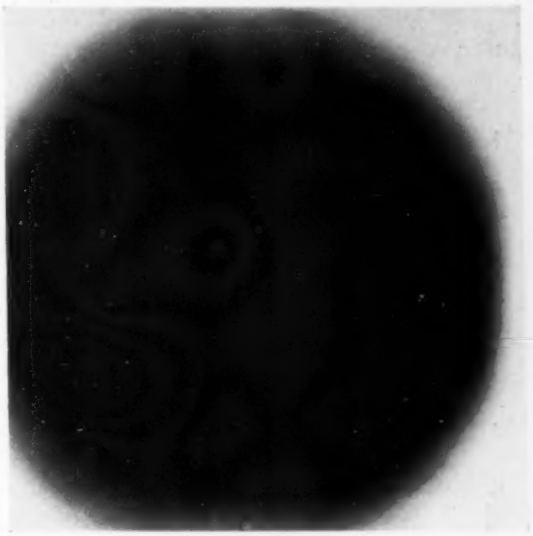

Fig. 15. Field of 15×15 cm. square cone.

To summarize, in most cases the cause for the non-uniformity of the roentgen-ray beam is any one of the following:

1. The target itself.
2. The tube being off center.
3. The improper opening in the tube head.
4. The window enclosing the oil in the tube head.
5. The master cone containing the ionization chamber or so-called intensimeter.
6. The upper limiting diaphragm of the cone.
7. The diaphragming of light devices or other attachments.

Therefore, even if the manufacturer has stated the distribution of the field when cones or other attachments are added, the field distribution should be investigated not only photographically, but chiefly by ionization measurements. Photographic measurements are very often deceiving for if the film is exposed too long or over-developed a non-uniform field will appear uniform.

The above examples were not selected but are almost consecutive findings. The field distribution is much more irregular than is assumed.

SUMMARY AND CONCLUSIONS

1. Roentgen-ray installations were measured to determine the uniformity of the field.

2. The most uniform fields measured for both oil cooled and water cooled equipment have an average deviation of about 25 per cent between the center and the periphery of a 30 cm. diameter field at 50 cm. focus-skin distance. The dosage rate on the anode side is about 73 per cent and on the cathode side about 85 per cent of that at the center.

3. One kind of installation containing an oil cooled tube oil immersed in which the outer enclosure was pyrex glass had a decrease in dosage rate from the center to the periphery of a 30 cm. diameter field of about 65 per cent at 50 cm. target-skin distance.

The cause for this non-uniformity is due to the limitation of the beam by the shape and placement of the window enclosing the oil.

4. Isodose curves are given for various planes and depths.

5. In one installation a field of 20×20 cm. had 35 per cent of the central dosage rate at the corners. The non-uniformity was due to the built-in ionization chamber in the master cone.

6. Improperly designed openings in cones changed a 20×20 cm. field into a 13×13 cm. field and a square field into a round field.

7. It is suggested that manufacturers or distributors of roentgen therapy apparatus state what the largest usable field is and give a description of its distribution by ionization measurements.

8. It is suggested when cones or other attachments are added that the field distribution be measured.

REFERENCE

1. Finzi, N. S. The tangential irradiation of breast carcinoma. *Radiology*, 1939, *33*, 312–315.

Vol. 46, No. 5

THE RELATIVE BIOLOGICAL EFFECTIVENESS OF ROENTGEN RAYS AND NEUTRONS ON THE REGENERATION OF THE FORELIMB OF *AMBLYSTOMA* LARVAE

By EDWARD C. HORN
Laboratory of Comparative Anatomy, Princeton University
PRINCETON, NEW JERSEY

INTRODUCTION

SINCE the first experiments on the biological effects of neutrons (Lawrence and Lawrence,[9] Zirkle and Aebersold[18]), there has been a steadily increasing amount of such work on a variety of biological materials. These first experiments showed that, per unit of ionization, neutron radiation is more effective than roentgen radiation in producing certain responses in several biological materials. Following this work there has been a number of investigations, testing the relative effectiveness of these two types of radiation on a variety of tissues (Lawrence, Aebersold and Lawrence,[8] Lawrence and Tennant,[10] Snell and Aebersold,[13] Zirkle, Aebersold and Dempster,[19] Spear, Gray and Read,[14] Zimmer and Timofeeff-Ressovsky,[16,17] Zirkle and Lampe,[20] Gray and Read,[7] Marshak,[11] Giles[6]). Of all these investigators only Zimmer and Timofeeff-Ressovsky found, within the dosages employed, that roentgen rays are more effective than neutrons; they studied the production of gene mutations in *Drosophila*. Recent work by Giles on the effects of neutrons on the chromosomes of *Tradescantia* demonstrates that the relationship between dosage and chromosome exchange break aberrations is linear, whereas it has been shown for roentgen irradiated material that the relationship is exponential, the exchanges increasing as the square of the dosage. From this result Giles concludes that, above a certain dosage of neutrons, which he calculates to be approximately 500 n, the neutron radiation is less effective than roentgen radiation, and below this value it is more effective.

The primary purpose of the present work has been to determine and to compare accurately neutron and roentgen-ray dosages with regard to their effectiveness in retarding and preventing tissue regeneration. The biological material used has been the regenerating forelimb of *Amblystoma* larvae. Since considerable work had already been done in this laboratory on the effects of roentgen rays on this same material (Butler,[1,2,3] Puckett,[12] Butler and Puckett[4]), the adaptability and limitations of the material were well known. The proximity of the Princeton cyclotron was an added factor prompting this problem. In the present paper some preliminary observations on the relative effectiveness of neutrons and roentgen rays on regenerating tissues are reported. This paper deals only with the physical measurements and relative effectiveness of neutrons and roentgen rays; a later paper will deal extensively with the tissue reactions which have been observed.

MATERIALS AND METHODS

Biological. The animals used for all experiments were *Amblystoma* larvae, reared in the laboratory from eggs. Animals of the same age period (forelimbs in late three-digit stage) were selected for both neutron and roentgen-ray experiments. All external conditions, temperature, feeding, etc., were kept as nearly constant as possible.

Normal regeneration or replacement of an amputated forelimb of an *Amblystoma* larva involves, first, the breakdown at the amputation level of formed structures such as cartilage and muscle; second, the formation at the tip of the amputated stump of a mass of undifferentiated cells, termed the blastema, the exact origin of which is at present uncertain; and, third, the differentiation and growth of the blastema into a fully formed limb. Under the control condi-

tions of the present experiments, the normal regenerative process proceeded about twenty days before the new limb reached the stage at which it had been amputated.

Immediately following irradiation with neutrons or roentgen rays both forelimbs were amputated through the middle of the humerus with iridectomy scissors. Control animals were operated on in the same manner.

For each dosage of neutrons and roentgen rays a series of animals in different stages of regeneration was collected. Since a detailed histological study of neutron irradiated material was planned, an irradiated animal and a control were killed each day following amputation for sixteen days and every other day thereafter, until thirty days after amputation had been reached. Additional animals were kept until forty days after amputation. As mentioned above, extensive work has been done on the effects of roentgen rays on regenerating amphibian tissues; for this reason, series of roentgen irradiated animals were less complete and were studied only to determine if regeneration took place at all.

All animals were fixed in Bouin's fluid, sectioned at 5μ and stained with Delafield's hematoxylin or Galigher's modified hemalum and counterstained with orange G.

Physical. The source of neutrons was a beryllium target bombarded by 6–8.5 Mev protons in the Princeton cyclotron. All dosage measurements were made with two 100 r bakelite Victoreen ionization chambers, and the readings are given in n units, an n being the amount of ionization produced by neutrons which gives the same reading on a 100 r Victoreen ionization chamber as does 1 roentgen of x-rays. All readings of neutrons dosages were kept below 25 n.

Since the animals must be kept separated at all times, a special box was designed to contain them during neutron irradiation, into which was fitted seven tiers of small glass compartments. These tiers were made of celluloid strips, 19.3×2.3 cm., on which were cemented in a row nine small glass cylindrical shells, 20 mm. in diameter. The tiers were piled one on another at the end of the box nearest the target. In this way a maximum of 63 animals could be irradiated at one time. This box was not placed directly in the neutron beam, but to one side, where the strength of the neutron field was reduced yet more uniform over the whole front of the box. To ascertain the uniformity of the field across the face of the box which held the animals, one 100 r chamber was placed between the target and animals within the box, and another was placed at a distance behind the animals but still within the box. Both chambers remained in these positions throughout the total irradiation period and were never interchanged during any experiment. Knowing the difference in readings between these two chambers, we determined the uniformity of the field at its top and bottom merely by upending one of the chambers in position and comparing readings again. No discrepancies were found in readings taken during experiments or during test periods when the box was used as a phantom. In all experiments each animal was assigned a definite position in the neutron field by numbering the tiers and compartments. Any discrepancies in dosage, exceeding the biological variability of the material, would have produced a result which could have been traced to a weaker or stronger portion of the beam; no discrepancies were found. The total dosage was the sum of the doses read from the 100 r chamber which was placed between the target and animals and contiguous with the latter. The animals were protected from gamma rays by plates of lead 1 inch thick which completely enclosed the box. Variation in neutron dosage, ranging from 10 to 103 n, was obtained by changing the exposure time.

The source of unfiltered roentgen rays was a 60 kv. Coolidge medium focus tube, operating at 6 ma.; the larvae were placed 25 cm. from the target. Dosage measurements were determined with the 100 r Victoreen chamber which was between the target and larvae during neutron irradiation. The tube produced 85 r per minute; again the length of exposure governed the dosage.

RESULTS

Six series of animals were exposed to 10, 20, 42, 62, 78, and 103 n respectively. A microscopical study of the sectioned animals revealed that the limbs of those which had received 62 n or more of neutrons had not regenerated.

During the course of normal regeneration, there is built up at the tip of the limb stump a compact mass of undifferentiated cells, the regeneration blastema. By growth and differentiation of this group of cells most of the regenerated tissues of the new limb are derived. In the age of larva used, cartilage is differentiated from the blastema

cells as a definite entity about thirteen days after amputation. In these experiments the appearance or absence of cartilage was taken as the criterion for the occurrence or absence of regeneration. Normally most of the new cartilaginous elements of the regenerating forelimb are outlined by the twentieth day of regeneration.

In all of the irradiated animals a blastema starts to form, but in those animals which receive 62 n or more of neutrons, the blastema cells gradually disappear after fifteen to twenty days of regeneration until by thirty days the limb stump is nothing but an epidermal bag filled with connective tissue, cell debris, a few cells, and the remains of the old humerus. In other words, the picture is, in all essential respects, similar to that given by earlier workers who used large dosages of roentgen rays to prevent regeneration.

Animals of series G, which received 42 n, show cartilage differentiating after the fourteenth day, but after forty days of regeneration only a spike of cartilage grows, and there is no sign of further activity or the formation of a more complete forelimb.

Animals of series F, which received 20 n, show cartilage formation at the end of thirteen days of regeneration, but by twenty-four days there is still only a single spike or digit. After thirty-five days, however, there is produced a fairly normal three-digit limb.

Animals of series H, which received 10 n, are impeded but slightly and regenerate practically a normal limb in the normal time.

Five series of animals were exposed to 425, 650, 850, 1,275, and 2,550 r of roentgen rays respectively. Those animals which received 850 r or more of roentgen rays showed no evidence of regeneration. The two series which received less than 850 r showed replacement of cartilage, and later they grew abnormal limbs which looked much like those described for the neutron irradiated animals.

DISCUSSION

The above results are conclusive in demonstrating that, so far as growth and differentiation of a new limb of *Amblystoma* larvae are concerned, neutrons are from thir-

Author	Material and Effects	X/N Ratio
Lawrence and Lawrence[9]	Depression of lymphocyte count in rats	About 10
	Lethal dose for rats	About 10
Lawrence, Aebersold and Lawrence[8]	Lethal dose for mice	3 to 4
	Destruction of sarcoma 180, *in vitro*	4 to 5.1
Snell and Aebersold[13]	Reduction in litter size of F_1 in irradiated male mice	5 to 6
Zirkle, Aebersold and Dempster[19]	Killing of *Drosophila* eggs	2.1
	Retardation of growth of wheat seedlings, variety "Big Club"	5
	Inhibition of fern spores (*Pteris*)	2.5
Zirkle and Lampe[20]	Killing of *Drosophila* eggs, $1\frac{1}{2}$ hour eggs	2
	Killing of *Drosophila* eggs, 4 hour eggs	3.2
	Killing of *Drosophila* eggs, 6 hour eggs	2.8
	Retardation in growth of wheat seedlings, variety "Nabob", Root	6.2 to 11.8
	Retardation in growth of wheat seedlings, variety "Nabob", Shoot	5.9 to 9
Marshak[11]	Production of chromosome abnormalities at anaphase, *Vicia faba*	6.6
	Production of chromosome abnormalities at anaphase, *Pisum sativum*	6.2
	Production of chromosome abnormalities at anaphase, *Solanum lycopersicum*	6.5
Giles[6]	Production of chromosome exchange break aberrations in *Tradescantia*	16 to 17

teen to fourteen times more effective than roentgen rays. As has been pointed out in previous comparisons of neutron-roentgen-ray effectiveness, the reason for the greater neutron effectiveness may be entirely the greater efficiency of the more intense ionization produced by recoil protons in tissue. However, in the California Radiation Laboratory data have been obtained (personal communication between Aebersold and White) which indicate that 1 n of neutron ionization actually represents about 2.5 times more ion pairs produced in tissue than does 1 roentgen of x-rays. Thus, per unit of ionization in tissue this work indicates that neutron induced ionization is from five to six times more effective than that induced by roentgen rays.

The accompanying table summarizes the results of other investigators who have determined the relative biological effectiveness of neutrons and roentgen rays on various animal and plant tissues. The extreme right-hand column contains the X/N (roentgen-ray-neutron) ratios of the different investigations, the X/N ratio being an expression for the equivalent doses of roentgen rays and neutrons, expressed in r and n respectively, necessary to produce the same effect or degree of effect in the materials investigated.

The present work deals with an entirely different group of animals and with an entirely different process from any yet investigated with neutrons, yet here again there can be no question of the greater efficiency of the neutrons as compared with roentgen rays in affecting this process. The effectiveness of both neutrons and roentgen radiation in preventing regeneration seems to be the result primarily of action of the radiation on the blastema cells proper and particularly on the mechanism controlling differentiation of these cells. In other words, the blastema of non-regenerating limbs never forms as completely as the normal blastema, and that part which forms at all does not possess the capacity to differentiate into new limb structures. This observation has already been made by Butler[2,3] and Butler and Puckett[4] for roentgen rays.

Since the blastema cells represent a type of tissue not too far removed from early neoplastic tissue, and since they are so much more sensitive to neutron radiation than to roentgen radiation, such work as that reported by Stone and Larkin[15] on the clinical use of neutrons would seem completely justified.

There is, however, one other aspect to be considered when neutron radiation is to be used for therapeutic purposes; that is the question of cumulative effects. Several animals which received doses of 103 n of neutrons were kept for a period of over two months after the time of amputation. Approximately a week before their death, they showed difficulty in feeding; examination then showed the eyes to be pathological and the animals to be blind. The animals could not be kept despite forced feeding and had to be sacrificed at the sixty-eighth day. Microscopic examination showed in every case complete breakdown of the lens, enlarged retina, a greatly enlarged and heavily pigmented iris and a thickened cornea. Further microscopic examination of the whole animal has revealed that portions of the gastrointestinal tract were also affected. These effects have often been reported for other animals as a result of roentgen treatment. In a review of the literature dealing with the effects of roentgen rays on the eye, Desjardins[5] discusses their action on the embryonic eye of several animals. It would seem that the roentgen-ray effects, if they are to take place at all, occur fairly soon after irradiation. In this neutron irradiated material, however, there were no signs of changes in the eye a month after irradiation.

As stated in the introduction, this paper is a preliminary report on the effect of neutrons on regenerating material. Since a more detailed study is to be presented shortly, further discussion will be withheld until then.

I am especially indebted to Professor E. G. Butler for his suggestions, advice and criticism of this problem and to Doctor M. G. White of the Princeton Physics Department for his advice and criticism particularly in the matter of dosage measurements.

I also wish to express my sincere thanks for the cooperation and cyclotron operation time so generously granted me by the cyclotron staff of the Princeton Physics Department.

SUMMARY

Regeneration of an amphibian limb depends primarily on proliferation and cellular differentiation of a mass of undifferentiated cells, the regeneration blastema. This regeneration blastema provides favorable material for a study of the effects of neutrons and roentgen radiation on the processes of growth and differentiation.

Sufficient doses of neutrons prevent differentiation and hence regeneration of the forelimb of *Amblystoma* larvae.

Neutrons are more effective per unit of ionization than are roentgen rays in preventing regeneration. A roentgen-ray dosage of thirteen to fourteen times that of the neutron dosage as measured in terms of ionization in a Victoreen 100 r chamber is necessary to prevent regeneration.

REFERENCES

1. Butler, E. G. X-radiation and regeneration in Amblystoma. *Science* 1931, *74*, 100.
2. Butler, E. G. Effects of x-radiation on the regeneration of the fore limb of Amblystoma larvae. *J. Exper. Zool.*, 1933, *65*, 271–315.
3. Butler, E. G. Studies on limb regeneration in x-rayed Amblystoma larvae. *Anat. Rec.* 1935, *62*, 295–307.
4. Butler, E. G., and Puckett, W. O. Studies on cellular interaction during limb regeneration in Amblystoma, *J. Exper. Zool.*, 1940, *84*, 223–239.
5. Desjardins, A. U. Action of roentgen rays and radium on the eye and ear. Am. J. Roentgenol. & Rad. Therapy, 1931, *26*, 639–679; 787–819; 921–942.
6. Giles, N. Effect of fast neutrons on the chromosomes of Tradescantia. *Proc. Nat. Acad. Sc.*, 1940, *26*, 567–575.
7. Gray, L. H., and Read, J. Quantitative comparison of biological effects of neutrons and other ionizing radiations. *Nature*, 1939, *144*, 509.
8. Lawrence, J. H., Aebersold, P. C., and Lawrence, E. O. Comparative effects of x-rays and neutrons on normal and tumor tissue. *Proc. Nat. Acad. Sc.*, 1936, *22*, 543–557.
9. Lawrence, J. H., and Lawrence, E. O. Biological action of neutron rays. *Proc. Nat. Acad. Sc.*, 1936, *22*, 124–133.
10. Lawrence, J. H., and Tennant, R. Comparative effects of neutrons and x-rays on the whole body. *J. Exper. Med.*, 1937, *66*, 667–688.
11. Marshak, A. Effects of fast neutrons on chromosomes in mitosis. *Proc. Soc. Exper. Biol. & Med.*, 1939, *41*, 176–180.
12. Puckett, W. O. Effects of x-radiation on limb development and regeneration in Amblystoma. *J. Morph.*, 1936, *59*, 173–213.
13. Snell, G. D., and Aebersold, P. C. The production of sterility in male mice by irradiation with neutrons. *Proc. Nat. Acad. Sc.*, 1937, *23*, 374–378.
14. Spear, F. G., Gray, L. H., and Read, J. Biological effects of fast neutrons. *Nature*, 1938, *142*, 1074.
15. Stone, R. S., and Larkin, J. C. Neutron beam therapy. Paper presented at the Conference on Applied Nuclear Physics, Cambridge, Oct. 31, 1940.
16. Zimmer, K. G., and Timofeeff-Ressovsky, N. W. Dosimetrische und strahlenbiologische Versuche mit schnellen Neutronen. *Strahlentherapie*, 1938, *63*, 528–536.
17. Zimmer, K. G., and Timofeeff-Ressovsky, N. W. Note on the biological effect of densely ionizing radiation. *Phys. Rev.*, 1939, *55*, 411.
18. Zirkle, R. E., and Aebersold, P. C. Relative effectiveness of x-rays and fast neutrons in retarding growth. *Proc. Nat. Acad. Sc.*, 1936, *22*, 134–138.
19. Zirkle, R. E., Aebersold, P. C., and Dempster, E. R. The relative biological effectiveness of fast neutrons and x-rays upon different organisms. *Am. J. Cancer*, 1937, *29*, 556–562.
20. Zirkle, R. E., and Lampe, I. Differences in the relative action of neutrons and roentgen rays on closely related tissues. Am. J. Roentgenol. & Rad. Therapy, 1938, *39*, 613–627.

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

Editor: LAWRENCE REYNOLDS, M.D. *Assistant Editor:* RUTH BIGELOW, B.S.

Editorial Board: A. C. CHRISTIE, M.D. E. H. SKINNER, M.D. LAURISTON S. TAYLOR
Advisory Board for Pathology: JAMES EWING, M.D. EUGENE L. OPIE, M.D.
Collaborating Editors: The Officers and Committee Members of the Societies of which this JOURNAL is the official organ, whose names appear on this page, are considered collaborating editors of this JOURNAL. *Foreign Collaborators:* GÖSTA FORSSELL, M.D., STOCKHOLM, G. F. HAENISCH, M.D., HAMBURG, R. LEDOUX-LEBARD, M.D., PARIS.

Publisher: CHARLES C THOMAS, 220 East Monroe St., Springfield, Illinois.

Issued Monthly. Subscription $10.00 per year, $11.00 in Canada and $12.00 in foreign countries. Advertising rates submitted on application: Editorial office, 110 Professional Building, Detroit, Mich., Office of publication 220 E. Monroe St., Springfield, Ill. Information of interest to all readers will be found on page iv.

Officers and Standing Committees

THE AMERICAN ROENTGEN RAY SOCIETY

President: W. M. Doughty, Cincinnati, Ohio; *President-Elect:* Ralph S. Bromer, Bryn Mawr, Pa.; *1st Vice-President:* F. W. O'Brien, Boston, Mass.; *2nd Vice-President:* F. J. Hodges, Ann Arbor, Mich.; *Secretary:* H. Dabney Kerr, University Hospital, Iowa City, Iowa; *Treasurer:* J. B. Edwards, 144 Woodridge Place, Leonia, N. J.; *Historian*, Ramsay Spillman, New York, N. Y.

Executive Council: W. M. Doughty, R. S. Bromer, F. W. O'Brien, F. J. Hodges, H. D. Kerr, J. B. Edwards, Lawrence Reynolds, C. M. Richards, V. W. Archer, H. M. Weber, M. C. Sosman, E. L. Jenkinson, B. P. Widman, C. H. Heacock, L. C. Kinney, Chairman, 1831 Fourth Ave., San Diego, Calif.

Program Committee: L. C. Kinney, San Diego, Calif., V. W. Archer, University, Va., H. D. Kerr, Iowa City, Iowa, H. M. Weber, Rochester, Minn., Lawrence Reynolds, Detroit, Mich., R. S. Bromer, Chairman, Bryn Mawr, Pa.

Publication Committee: E. P. Pendergrass, Philadelphia, Pa., U. V. Portmann, Cleveland, Ohio, H. M. Weber, Chairman, Rochester, Minn.

Finance Committee: J. C. Peden, St. Louis, Mo., F. B. Bogart, Chattanooga, Tenn., C. M. Richards, Chairman, San Jose, Calif.

Committee on Scientific Exhibits: P. A. Bishop, Philadelphia, Pa., S. W. Donaldson, Ann Arbor, Mich., V. W. Archer, Chairman, University, Va.

Member, National Research Council: Ross Golden, New York City.

Editor: Lawrence Reynolds, 110 Professional Building, Detroit, Mich.

Assistant Editor: Ruth Bigelow, 110 Professional Building, Detroit, Mich.

Editorial Board: A. C. Christie, E. H. Skinner, Lauriston S. Taylor.

Advisory Board for Pathology: James Ewing, Eugene L. Opie.

Forty-third Annual Meeting: 1942, Atlantic City, N. J.

THE AMERICAN RADIUM SOCIETY

President: Hayes E. Martin, New York, N. Y.; *President-Elect:* William E. Costolow, Los Angeles, Calif.; *1st Vice-President:* J. E. Gendreau, Montreal, P. Q.; *2nd Vice-President:* George C. Wilkins, Manchester, N. H.; *Secretary:* A. N. Arneson, 4952 Maryland Ave., St. Louis, Mo.; *Treasurer:* Charles L. Martin, 3501 Gaston Ave., Dallas, Tex.

Executive Committee: W. P. Healy, Chairman, New York, N. Y., L. A. Pomeroy, Cleveland, Ohio, F. W. O'Brien, Boston, Mass.

Program Committee: W. E. Costolow, Chairman, Los Angeles, Calif., G. T. Pack, New York, N. Y., P. A. Nelson, Chicago, Ill., E. T. Leddy, Rochester, Minn.

Publication Committee: E. H. Skinner, Chairman, Kansas City, Mo., Zoe A. Johnston, Pittsburgh, Pa., Wilbur Bailey, Los Angeles, Calif.

Research and Standardization Committee: Edith H. Quimby, Chairman, New York, N. Y., J. L. Weatherwax, Philadelphia, Pa., W. S. MacComb, New York, N. Y.

Education and Publicity Committee: A. W. Oughterson, Chairman, New Haven, Conn., L. R. Cowan, Salt Lake City, Utah, J. F. Hynes, Wilmington, Del.

Janeway Lecture Committee: Douglas Quick, Chairman, New York, N. Y., E. H. Skinner, Kansas City, Mo., G. Failla, New York, N. Y., W. P. Healy, New York, N. Y., L. A. Pomeroy, Cleveland, Ohio, F. W. O'Brien, Boston, Mass.

Committee on Arrangements: J. E. Wirth, Chairman, Baltimore, Md., J. G. Spackman, Wilmington, Del., J. V. Blady, Philadelphia, Pa.

Representatives on American Board of Radiology: Douglas Quick, New York, N. Y., R. H. Stevens, Detroit, Mich., B. P. Widmann, Philadelphia, Pa.

Twenty-seventh Annual Meeting: Atlantic City, N. J., June 8–9, 1942.

EDITORIAL

THE ANNUAL MEETING

THE annual meeting held at Cincinnati, Ohio, from September 23 to 26, 1941, was the forty-second in the history of the American Roentgen Ray Society and it is doubtful whether throughout those years the Society has ever had a more attractive program or a more interesting meeting. President-Elect Doughty and his committees arranged a scientific program of great interest and a program of entertainment which will long be remembered by those present at the meeting. From the call to order on the first day of the meeting by President Sosman and the stimulating address of welcome given by Dr. Raymond D. Walters, President of the University of Cincinnati, up to the closing remarks on Friday afternoon the last day of the meeting, there was nothing but pleasant entertainment for the mind and body. One of the outstanding features of the meeting was the various symposia that were arranged dealing with many phases of roentgenologic problems in diagnosis and treatment.

The annual Caldwell Lecture was given by Dr. John H. Lawrence of the University of California on "The New Nuclear Physics and Medicine" and was a stimulating and thought-provoking discussion on an intensely interesting and important subject.

The banquet on Thursday evening was unusually well arranged and was a social feature which will not be soon forgotten. Heretofore at some of the meetings too little attention has been given to the program for the evening of the banquet but certainly the most exacting could find no fault with this year's arrangement in the hands of Dr. Doughty and his local committees.

The Annual Golf Tournament, an eighteen hole match for the Willis F. Manges Trophy and the Exhibitors' Trophy, was unusually well attended and this was followed by a dinner in the evening which was attended by nearly all the members present.

To the local Ladies Committee, of which Mrs. E. R. Bader was Chairman, the Society is indebted for a splendid program of entertainment for the wives and guests of those present at the meeting.

The Instruction Courses in charge of Dr. B. R. Kirklin, which have become an annual feature of the Society's meetings, proved to be of unusual interest at the Cincinnati gathering and attracted a great number of guests as well as members.

The Scientific Exhibit was of unusual scope and interest and to the Chairman, Dr. Paul A. Bishop and members of that committee the Society is indebted for the excellent arrangement and disposition of the exhibits. A detailed report of these exhibits is given elsewhere in this issue of the JOURNAL.

The central geographic location of Cincinnati attracted a great number of Commercial Exhibitors and in the Hall of Mirrors of the Hotel was displayed one of the most comprehensive exhibits which it has ever been the pleasure of the members of the Society to see, and to the exhibiting corporations and to the men in charge of the various technical exhibits, the Society offers its thanks and appreciation.

The great interest that was manifested in this year's meeting of the Society is attested to by the number of registrations; a total of 740 attended, of which the members represented 209, guests 394, and commercial exhibitors 137.

The Netherland Plaza proved to be an ideal meeting place because of the splendid arrangements of the various rooms and the large halls which lend themselves so admirably to meetings and exhibits, and secondly because of the courteous and efficient

manner in which all the details of the Society's programs and needs were handled by the Hotel's personnel.

Under the guiding hand of President-Elect Doughty and his splendid group of local committees the Cincinnati meeting of the American Roentgen Ray Society was an event which will be remembered as one of the most pleasant and successful in the long history of this organization.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual Meeting: 1942, Atlantic City, N. J.

American College of Radiology
Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill. Annual meeting: Atlantic City, N. J., June 10, 1942.

Section on Radiology, American Medical Association
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: Atlantic City, N. J., June 8–12, 1942.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: Fairmont Hotel, San Francisco, Calif., Nov. 30–Dec. 5, 1941.

Radiological Section, Baltimore Medical Society
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

Section on Radiology, California Medical Association
Secretary, Dr. J. D. Coate, 434 Thirtieth St., Oakland, Calif.

Radiological Section, Connecticut Medical Society
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary. Annual meeting in May.

Section on Radiology, Illinois State Medical Society
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

Radiological Section, Los Angeles Co. Med. Soc.
Secretary, Dr. Wilbur Bailey, 2007 Wilshire Blvd., Los Angeles, Calif. Meets on second Wednesday of each month at County Society Building.

Radiological Section, Southern Medical Association
Secretary, Dr. Roy G. Giles, Temple, Texas.

Brooklyn Roentgen Ray Society
Secretary, Dr. Leo Harrington, 880 Ocean Ave., Brooklyn, N. Y. Meets monthly on fourth Tuesday, October to April.

Buffalo Radiological Society
Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months.

Chicago Roentgen Society
Secretary, Dr. C. J. Challenger, 3117 Logan Blvd. Meets second Thursday of each month October to April inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, J. O. Newton, 13921 Terrace Rd., East Cleveland. Meets at 6:30 P.M. at Midday Club on fourth Monday each month, October to April, inclusive.

Denver Radiological Club
Secretary, Dr. Edward J. Meister, 366 Metropolitan Bldg., Denver, Colo. Meets third Friday of each month at Denver Athletic Club.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

Florida State Radiological Society
Secretary, Dr. Walter A. Weed, 204 Exchange Bldg., Orlando, Florida. Meetings in May and November.

Georgia Radiological Society
Secretary, Dr. R. C. Pendergrass, Prather Clinic Bldg., Americus, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

Illinois Radiological Society
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

Indiana Roentgen Society
Secretary, Dr. H. C. Ochsner, Methodist Hospital, Indianapolis. Meeting held the second Sunday in May annually.

Kentucky Radiological Society
Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in April.

Long Island Radiological Society
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

Louisiana Radiological Society
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society meeting. Next meeting New Orleans, April, 1942.

Michigan Association of Roentgenologists
Secretary, Dr. J. E. Lofstrom, 1536 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

Milwaukee Roentgen Ray Society
Secretary, Dr. I. I. Cowan, Mt. Sinai Hospital, Milwaukee, Wis. Meets monthly on first Friday at University Club.

Minnesota Radiological Society
Secretary, Dr. J. P. Medelman, 572 Lowry Medical Arts Bldg., St. Paul.

Nebraska Radiological Society
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

New England Roentgen Ray Society
Secretary, Dr. A. O. Hampton, Massachusetts General Hospital, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

Radiological Society of New Jersey
Secretary, Dr. H. J. Perlberg, 921 Bergen Ave., Jersey City. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

New York Roentgen Society
Secretary, Dr. Paul C. Swenson, Presbyterian Hospital, New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

North Carolina Roentgen Ray Society
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

North Dakota Radiological Society
Secretary, Dr. L. A. Nash, St. John's Hospital, Fargo. Meetings held by announcement.

Central New York Roentgen Ray Society
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

Ohio Radiological Society
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati. Meets at time and place of annual meeting of Ohio State Medical Association.

Pacific Roentgen Society
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport.

Philadelphia Roentgen Ray Society
Secretary, Dr. B. R. Young, Temple University Hospital. Meeting first Thursday of each month from October to May inclusive at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

Pittsburgh Roentgen Society
Secretary, Dr. H. W. Jacox, 4800 Friendship Ave. Meets second Wednesday each month, 4:30 P.M., October to June, Pittsburgh Academy of Medicine.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. S. C. Davidson, 277 Alexander St. Meets on second Thursday from October to May, inclusive. 8 P.M., Rochester Academy of Medicine Building.

Rocky Mountain Radiological Society
Secretary, Dr. A. M. Popma, 220 N. First St., Boise, Idaho, Annual meeting in Denver, summer of 1942.

St. Louis Society of Radiologists
Secretary, Dr. W. K. Mueller, University Club Bldg. Meets fourth Wednesday of October, January, March and May, at a place designated by the president.

San Francisco Radiological Society
Secretary, Dr. H. A. Hill, 450 Sutter St., San Francisco. Meets monthly on third Thursday at 7:45 P.M., first six months at Toland Hall, second at Lane Hall.

South Carolina X-Ray Society
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. F. B. Bogart, 311 Medical Arts Bldg., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. L. W. Baird, Scott and White Clinic, Temple, Texas. Next annual meeting, Houston, Texas, February 7, 1942.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

Virginia Radiological Society
Secretary, Dr. C. H. Peterson, 603 Medical Arts Bldg., Roanoke, Va. Meets annually in October.

Washington State Radiological Society
Secretary, Dr. K. J. Holtz, American Bank Bldg., Seattle. Meets fourth Monday each month, College Club, Seattle.

X-ray Study Club of San Francisco
Secretary, Dr. J. M. Robinson, University of California Hospital. Meets monthly in evening on third Thursday.

Cuba

Sociedad de Radiología y Fisioterapia de Cuba
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets monthly on third Thursday from November to June inclusive, at 8:15 P.M., 32 Welbeck St., London.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine 1, Wimpole St., London, W. 1.

Faculty of Radiologists
Secretary, Dr. M. H. Jupe, 32 Welbeck St., London, W. 1 England.

Section of Radiology and Medical Electricity, Australasian Medical Congress.
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive.

Canadian Association of Radiologists
Secretary, Dr. A. C. Singleton, Medical Arts Bldg. Toronto, 5, Ontario.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N.S.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

Continental Europe

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse Biel. Meets annually in different cities.

Societa Italiana Radiologia Medica
Secretary, Prof. M. Ponzio, University of Turin, Turin.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

Orient

Japan X-Ray Association
c/o Orthopedic Surgery, Tokyo Imperial University. Meets annually in April.

Kinki Roentgen-Abend Society
Director, Dr. Prof. Taiga Saito, Ogawaoike Tyoto, Japan. Meets bi-monthly on third Sunday.

BULLETIN OF THE AMERICAN COLLEGE OF RADIOLOGY

POINTS OF INTEREST

The following bulletin was sent to State Councilors of the American College of Radiology and secretaries of all regional radiological societies on August 27:

Resolution of the American Medical Association

At its June meeting in Cleveland, the House of Delegates of the American Medical Association instructed the Board of Trustees to confer with representatives of the American Hospital Association and the Protestant and Catholic hospital associations to clarify the relation of medical services in prepayment hospitalization and similar plans, "the same to be in line with the basic principles laid down in the past by the House of Delegates." These basic principles expressly demand that radiology be treated as a medical service and not included as a part of hospital service along with benefits offered in group hospitalization.

The House of Delegates also approved the report of a reference committee recommending that "Special societies, such as radiologists, pathologists, and anesthesiologists, recommend to their members that they defer entering into contractual relationships with hospitals involved in medical service plans until the relationship has been thoroughly clarified. . . ."

Also approved was a resolution recommending that "Wherever obtainable, hospitals should have doctors of medicine especially trained in pathology, radiology, anesthesiology, and physical medicine as directors in charge of these respective departments, and that the directors of these departments shall be eligible for membership on their respective medical staffs or medical boards with voice and vote."

Hospital Exploitation

Of special interest to radiologists is an article appearing in the August *Atlantic Monthly* by Dr. Miles Atkinson, a New York surgeon who came to this country from England a few years ago, under the title "The Patient Comes First." In discussing the parlous state of overcapitalized hospitals, Dr. Atkinson concludes that they have resorted to some dubious practices. He says, "Another widespread practice that is generally accepted, though it is difficult to see why, is that of working the pathological and x-ray departments deliberately at a profit—the charges are such that income is higher than expenses. The difference, or the profit, goes into the funds of the institution. As it was put very truly in a medical paper not long ago, 'The arithmetical difference between the total cost of operation and the total profit derived . . . is certainly represented by the individual services of the medical personnel'; but funds which represent professional training and specialist knowledge are diverted from the doctors to the institution."

Selective Service Examinations

Information reached this office a few days ago to the effect that the national Selective Service headquarters had adopted a uniform schedule for use throughout the nation in reimbursing radiologists for costs incurred in examining selectees. An inquiry to Clarence Dykstra, director of Selective Service, reveals that this report is erroneous. Each state will be expected to adopt and operate under its own cost schedule. Approximately three-fourths of the states are operating under a schedule which reimburses radiologists upon a basis of 50 per cent of customary private fees. In a few states the schedule is lower.

Medical Service Plans

More state medical societies are following the precedent of California, Michigan, New Jersey and New York and are preparing to install prepayment medical service plans for groups of employed subscribers in designated low income brackets. In connection with these plans, two points are of paramount interest to radiologists: (1) ra-

diology should be included along with other medical services whether the plan embraces complete medical care or is for hospitalized surgery alone; it should not be included as a part of hospital care in the benefits paid for hospitalization; (2) some deterrent should be placed upon the use of roentgen diagnosis, else the expenses for this service alone may render the plan actuarially unsound. A maximum allowance for radiology may be determined, or the subscribers may be required to pay a certain portion of fees charged for roentgen diagnosis.

Anent the subject of medical service plans, an interesting article, "But Health Insurance Is Different," by Nathan Sinai, appears in the August *Harper's*, page 275.

NYA

The NYA program calling for chest examinations on some 500,000 youths in the country each year is undergoing sporadic development in various sections of the country. It appears that plans and procedures are subject to the discretion of the NYA director in each state. In some states the program is well under way, while in others nothing has been done. In Iowa, Virginia, Florida, and a few other states, an agreed method and rate for reimbursement of radiologists performing chest examinations has been adopted. In several states radiologists have decided against working at the hourly rates allowed by NYA, and have preferred to let the chest examinations be performed by public agencies or tuberculosis associations. This subject was discussed at great length by the Board of Chancellors of the College of Radiology during its meeting in June, and it was decided that the decision on this matter should be left up to the radiological societies in each locality.

Locum Tenens Contracts

In our bulletin[1] of April 16, 1941 (RS-61) we submitted the resolution adopted by the College of Radiology pertaining to the protection of civil practices of radiologists called for military duty. In that bulletin we recommended that a radiologist leaving a hospital practice make a personal contract with his locum tenens instead of permitting the hospital to select someone to fill his position during his absence. Such contracts should be prepared only with the assistance of a competent attorney, and should include provisions for disposition of income from the practice and a restrictive covenant to protect the absentee's practice after he returns to the community. For a general discussion of locum tenens contracts, see *Medical Economics* for July, 1941, page 42. Members wishing sample or suggested contracts for a locum tenens should write to the headquarters office of the College.

[1] AM J. ROENTGENOL. & RAD. THERAPY, July, 1941, *46*, 124.

Military Affairs

No very definite estimate of the number of radiologists that will be required for the armed forces, either for defense or war, has been forthcoming from military circles. Neither have we any accurate idea of the number of radiologists already called to active duty. The contact of the College of Radiology with the responsible Army and Navy officials has been less than satisfactory, and this subject was a matter of lengthy discussion during the last meeting of the Board of Chancellors. Vincent W. Archer, Chairman of the Board, has asked the present Advisory Committee on Radiology to the National Research Council to act as the College Committee on Military Affairs. Henceforth it will be the point of contact between organized radiology and national defense agencies. The committee is composed of Dr. A. C. Christie, chairman, Dr. B. R. Kirklin, Dr. U. V. Portmann, and Dr. W. Edward Chamberlain.

Inter-Society Committee for Radiology

Pursuant to amendments to the Constitution and By-Laws of the College of Radiology, the activities carried on by the Inter-Society Committee for Radiology for the past three years have been taken over

by the College. At its last meeting the Board of Chancellors enlarged the Inter-Society Committee by adding to it the representatives on the Board of Chancellors nominated by the American Roentgen Ray Society, the Radiological Society of North America, and the American Radium Society. Now called the Inter-Society Commission on Economics, the committee is composed of the original three, Dr. A. C. Christie, Dr. E. H. Skinner and Dr. L. S. Goin, with the addition of Dr. E. L. Jenkinson, Chicago, Dr. L. H. Garland, San Francisco, and Dr. F. W. O'Brien, Boston.

Group Hospitalization

For years organized radiology has warned that the spectre of hospital domination and exploitation was a threat to the integrity of all medicine. Full appreciation of this fact has not always been manifested when radiologists appealed for support from their local colleagues in a fight to keep radiology from being offered as a part of hospital care among benefits in a group hospitalization plan. Of late an increasing number of leaders in organized medicine have come to the realization that we were not merely crying "Wolf!" An editorial in the August *Medical Economics* (page 20) is of interest: "When the first of the three resolutions referred to was introduced at the St. Louis convention [of the A. M. A.] in 1939, it related almost exclusively to the status of radiologists, pathologists, and anesthesiologists; for these were about the only medical men whose services were likely to be included in a group hospitalization policy. Since then, conditions have changed materially. Hospital groups are now putting the finishing touches on a vast new prepayment plan which, it is predicted, will provide millions of low-income citizens with both hospitalization and medical care. This is bound to affect not only the physicians in the three specialities named but—more important—all physicians in virtually all other branches of medicine."

Mac F. Cahal
Executive Secretary

SCIENTIFIC EXHIBIT

To add to the general interest of the Forty-second Annual Meeting of the American Roentgen Ray Society held in Cincinnati, Ohio, September 23 to 26, 1941, an extensive exhibit touching upon a wide range of subjects was arranged by the Committee on Scientific Exhibits composed of Dr. Paul A. Bishop, Chairman, Dr. V. W. Archer and Dr. S. W. Donaldson. These exhibits were attractively grouped in a hall large enough to accommodate them without crowding, and to permit the addition of comfortable chairs and davenports which gave an opportunity for relaxation and discussion by those viewing the exhibits.

A brief outline is given of the various subjects presented.

THORAX

In the section on the thorax was an exhibit by Drs. Eugene P. Pendergrass, S. Reid Warren, and D. E. Haagensen from the Department of Radiology and the Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, on "A Study of Comparative Methods of Chest Roentgenograms."This comprised a detailed study of the diagnostic value of the four methods of chest roentgenography, namely: film 14″ by 17″, paper 14″ by 17″, stereo 4″ by 5″, and stereo 35 mm. Adult patients were carefully selected to show the relative value of these methods in minimal tuberculosis and silicotic conditions of the lungs.

Dr. Pedro L. Fariñas, Habana, Cuba, presented the subject of "Mucosography of the Respiratory Tract." The purpose of this exhibit was to show that the roentgen examination of the tracheobronchial mucosa, coated with a very thin opaque layer gives useful information of the internal surface of the larynx, trachea and bronchi. The technique is simple and harmless.

An exhibit by Drs. Marcy L. Sussman, M. F. Steinberg and A. Grishman, Mount Sinai Hospital, New York, was entitled "Congenital and Rheumatic Heart Disease." The cardiac chambers, pulmonary

artery and aorta were visualized in a comprehensive group of cases of rheumatic and congenital heart disease, following the intravenous injection of a 70 per cent solution of diodrast. A newly designed apparatus permitted making eight roentgenograms in approximately ten seconds. Each case was shown completely, including clinical data, electrocardiogram, phonocardiogram, etc.

An exhibit entitled "Heart Studies" was presented by Dr. Asa E. Seeds, Baylor University Hospital, Dallas, Texas. This work was an attempt to indicate a significant simplicity in teleroentgen studies of normal cardiac shadows. It tended to indicate that a solid foundation in the knowledge of the normal variation plot is necessary to properly evaluate such studies, and that, without it, even the more complicated methods give inaccurate results.

The final exhibit in this section was "The Value of Roentgen Therapeutic Test Doses in the Differential Diagnosis of Mediastinal Tumor" by Drs. Lawrence Reynolds and Traian Leucutia, Harper Hospital, Detroit, Michigan. This exhibit demonstrated the value of the roentgen therapeutic test dose as applied during the past twenty years in the differential diagnosis of mediastinal tumors. The final individual results obtained with the aid of this method were illustrated with transparencies of roentgenograms, photographs and photomicrographs. A classification of mediastinal tumors according to the degree of radiosensitivity was given in a series of tables. This exhibit was awarded a Certificate of Merit.

SKELETON

The subject of "Osteochondrodystrophies in Infants and Children" was presented by Drs. Ralph S. Bromer and R. M. Harvey, Children's Hospital, Philadelphia. It included roentgenograms illustrating achondroplasia, osteochondrodystrophy, lipochondrodystrophy and other bone dystrophies occurring in infants and children, with charts describing essential points in the differential diagnosis of these conditions.

From the College of Medicine, University of Cincinnati, Cincinnati, Ohio, was an interesting exhibit entitled "Post-traumatic Osteoporosis" by Drs. Louis G. Herrmann, John A. Caldwell and Harold G. Reineke. This was a presentation of a picture story of acute neurotrophic disturbances in small bones of the extremities which follow in the wake of trivial as well as serious trauma. Serial roentgenograms were shown representing all phases of this disease entity and the clinical picture of the disease was discussed in relation to the changes in the bones. The effect of therapy upon the roentgenologic changes as well as upon the clinical course of the disease was presented, as well as several instances of the rarer forms of neurotrophic disturbances in bone. This exhibit received the second highest award, that of the Bronze Medal.

Dr. Hoke Wammock, Jeanes Hospital, Philadelphia, presented an exhibit on "Irradiation Fractures of the Rib Cage." This consisted of roentgenograms demonstrating irradiation fractures of the ribs and a group of patients who had received interstitial radium element needles in combination with deep roentgen therapy for carcinoma of the breast. These fractures have been observed by repeated roentgen studies over a period of five years or more.

Drs. Harold W. Jacox and Paul Gross of the Western Pennsylvania Hospital, Pittsburgh, had an exhibit entitled "The Status of Eosinophilic Granuloma of Bone." This included illustrative roentgenograms and photomicrographs, as well as a chart which was a diagrammatic representation of the interrelationship between certain of the reticulo-endothelioses. The diseases included were Schüller-Christian's, Letterer-Siwe's, solitary xanthoma of bone and eosinophilic granuloma of bone, as well as the reticulo-endothelioses which are in intermediate position between these various conditions.

"Skeletal Malformations in the Offspring of Rats Reared on a Deficient Diet" was the title of an exhibit by Drs. Josef Warkany and Rose C. Nelson, Children's Hos-

pital Research Foundation, Cincinnati, Ohio. Specimens of newborn rats cleared by the Schulte-Dawson method were shown in an illuminated box. The offspring of mothers reared and bred on a deficient diet show a variety of congenital malformations. Shortening of the mandible, tibia, fibula, radius and ulna can be seen. In addition, fusion of the ribs, syndactylism of the fingers and toes and premature and irregular fusion of the sternebrae can be demonstrated. As controls, similar preparations of the offspring of mothers reared and bred on an adequate diet were shown. This interesting exhibit received a Certificate of Merit.

An exhibit entitled "The Sphenoidal Fissure" was offered by Drs. Karl Kornblum and George R. Kennedy, Jefferson Medical College and Hospital, Philadelphia. An anatomical and roentgenological study was made of the sphenoidal fissure of the skull in order to determine the normal size and shape of this structure. It has been found that the sphenoidal fissure is often deformed in the presence of intracranial pathology, especially when neoplastic in nature. Cases have been collected in which deformity of the sphenoidal fissure was of value in diagnosis of intracranial lesions. Attention to the sphenoidal fissure will often aid in the lateralization of the intracranial pathological condition. A Certificate of Merit was awarded this exhibit.

A most interesting and timely exhibit was presented by Dr. Oscar V. Batson of the Graduate School of Medicine, University of Pennsylvania, Philadelphia, on "The Vertebral Vein System." The vertebral vein system parallels and forms a by-pass for the caval and pulmonary circulations. For this reason metastases can proceed along the vertebral veins to find lodgment in the brain, shoulder and pelvic girdles and other parts without entering the lung circulation and hence without producing pulmonary metastases. Roentgenograms showed the anatomic extent and the many communications of this vast venous reservoir. Roentgenograms of cadavers after the injection of radiopaque masses are ideal for studying the essential anatomy of these vessels. This exhibit received the highest award given, that of the Silver Medal.

Gastrointestinal Tract

"The Gastrointestinal Tract in the Healthy Newborn Infant" was the title of an exhibit by Dr. Samuel G. Henderson, Magee Hospital, Pittsburgh. This consisted of roentgenograms of the stomach and intestinal tract in a group of one hundred healthy newborn infants, following administration of barium in various forms by mouth. In thirty of the group of one hundred, a detailed small bowel study was made and a number of roentgenograms showing the typical small bowel pattern were included in the exhibit.

Drs. Fred M. Hodges, Lawrence O. Snead and R. A. Berger, Richmond, Virginia, had arranged an interesting exhibit on "A Stellate Impression in the Cardiac End of the Stomach Simulating a Tumor." This comprised the study and appearance of the mucosal folds at the gastro-esophageal orifice and included original films which showed the various types of stellate impressions in the cardiac end of the stomach which may simulate tumor. A Certificate of Merit was awarded this exhibit.

"The Meniscus Sign Complex" was the title of an exhibit by Dr. B. R. Kirklin, Mayo Clinic, Rochester, Minnesota, and consisted of drawings, roentgenograms and photographs of specimens selected and arranged to demonstrate the importance of the meniscus sign complex in the recognition of small ulcerating cancers of the stomach.

Another exhibit having reference to the gastrointestinal tract was presented by Drs. Joseph C. Bell and William J. Martin, Louisville, Kentucky, and was entitled "Polypoid Lesions of the Small Bowel." This consisted of fourteen 14" by 17" roentgenograms of the colon showing polyps of the large bowel by the double contrast method, together with two other films made after the ordinary type of contrast enema,

in individuals with diffuse polyposis. The latter, together with the double contrast films made in the same cases, showed the value of the latter method of examination. There were included numerous charts showing the incidence of polypoid lesions found during routine sigmoidoscopic examinations, together with others showing the relationship between polypoid lesions and malignant lesions found in the same areas.

Genitourinary System

"Sterility Cured by Hysterosalpingography" was the title of an exhibit by Dr. Charles L. Martin, Dallas, Texas. A combined CO_2 and lipiodol technique with continuous oil pressure was illustrated with serial roentgenography. In most of the cases, closed fallopian tubes were opened and pregnancy occurred subsequently. A Certificate of Merit was awarded this exhibit.

NEUROLOGICAL

Among the exhibits in this final group was included one by Drs. Cornelius G. Dyke, Abner Wolf and John Caffey, Neurological Institute, New York, on "Infantile Toxoplasmic Encephalomyelitis." A protozoan encephalomyelitis described as occurring in infants (Wolf and Cowen, 1937) was later identified as a form of human toxoplasmosis (Wolf, Cowen and Paige, 1939), by transmission of the infection to animals. Toxoplasma is a protozoan which in smears appears crescentic in shape, measures 4 to 6 microns in length and 2 to 3 microns in width. It is pointed at both ends or has one blunt end, and has a central chromatin body. Although it is of uncertain classification, it is characterized by an affinity for many tissues, especially the central nervous system, widespread geographic distribution and pathogenicity for a wide variety of hosts. Infantile toxoplasmic encephalomyelitis has a specific pathologic picture characterized by necrotizing chronic inflammatory lesions, miliary granulomata, conspicuous calcification, frequent hydrocephaly and focal choreoretinitis. The symptoms and signs of widespread cerebral damage, roentgenographic evidence of internal hydrocephaly and cerebral calcification, the ophthalmoscopic observation of a striking choreoretinitis and the presence in the blood of neutralizing antibodies to toxoplasma have led to the clinical diagnosis of a series of cases. The roentgenographic findings in these cases were presented and their characteristic features given.

Dr. Charles W. Perkins, Norwalk, Connecticut, presented an exhibit on "Craniopharyngioma: Cyst of Rathke's Pouch" which consisted of roentgenograms of a case, with hypopituitarism, hypothyroidism and hypogonadism. The patient was twenty-four years old and had an epiphyseal development of fourteen to sixteen years. His mentality was high and his voice high pitched. There were slipped epiphyses on the left side. Improvement occurred after operation.

"Intraspinal Iodized Oil: Removal of Lipiodol by Lumbar Puncture" was the title of an exhibit by Drs. Aubrey O. Hampton and Charles S. Kubic, Massachusetts General Hospital, Boston. Lipiodol can be removed completely from the lumbar subarachnoid spaces by means of a simple lumbar puncture. The technique of this procedure was illustrated.

Drs. William A. Nosik and W. James Garnder, Cleveland Clinic, Cleveland, presented the subject of "Intraspinal Thorotrast." Approximately forty-two consecutive roentgenograms of the spine after the injection of thorotrast were shown. The clarity of anatomic detail was demonstrated as well as the effective application and the results thereof, in the elimination of the medium following its use. This exhibit was awarded a Certificate of Merit.

Another exhibit dealing with the spine was entitled "Intraspinal Air: Herniated Discs, Tumors and Other Intraspinal Lesions Visualized by Injection of Air" by Drs. Barton R. Young and Michael Scott, Temple University Hospital and Medical School, Philadelphia. This was made up of roentgenograms showing the various types

of defects of the spinal subarachnoid space produced by disc protrusions, tumors, thickened ligamentum flavum and arachnoiditis. A number of illustrative myelograms emphasized the value of the method to show the exact level of a lesion that is producing a partial or complete block. The reduction effect of hyperflexion on a mobile herniated disc and the exaggeration of the protrusion produced by hyperextension was illustrated by roentgenograms of the spine made with the patient in these positions. The normal anatomy of the spinal canal in the cervical, dorsal and lumbosacral regions, as determined by the subarachnoid injection of air was demonstrated in children and adults.

"Low Voltage Contact Roentgen Radiation in the Treatment of Cancer of the Bladder" was the subject of an exhibit by Dr. Lowell S. Goin, Los Angeles. This consisted of a beautiful motion picture demonstration of the technique, colored transparencies and a chart.

An exhibit by Dr. C. A. Stevenson, Temple, Texas, was entitled "Cholecystitis with Emphysema" and consisted of the demonstration of two cases, correctly diagnosed before operation, and successfully treated.

COMMERCIAL EXHIBIT

At any meeting of the American Roentgen Ray Society the manufacturers can always be depended upon to do their share toward making the occasion one where those in attendance have an opportunity to obtain a complete picture of all that is new in the radiological field. Of great importance are the new developments in equipment both from the diagnostic and therapeutic viewpoint. In no other place, with the expenditure of less time and effort, can the radiologist gain such a complete picture of the technical advances made in his field as at the Commercial Exhibit of one of the radiological societies. The exhibit at the Forty-second Annual Meeting of the American Roentgen Ray Society held in Cincinnati, Ohio, September 23 to 26, 1941, proved no exception to this statement. The exhibits were placed in the Hall of Mirrors and adjoining foyer in the Netherland Plaza and showed to excellent advantage in this beautiful setting. The exhibit was the most extensive the Society has ever had and as always the Society is most appreciative of the time and thought given by the manufacturers in producing exhibits of such general attractiveness and value. The following were represented at the Cincinnati meeting: *Agfa Ansco*, Binghamton, N. Y., *Buck X-Ograph Company*, St. Louis, Mo., *Canadian Radium and Uranium Corporation*, New York, N. Y., *DuPont Film Manufacturing Corporation*, New York, N. Y., *Eastman Kodak Company*, Rochester, N. Y., *W. E. Falk*, Cincinnati, Ohio, *General Electric X-Ray Corporation*, Chicago, Ill., *Kelley-Koett Manufacturing Company*, Covington, Ky., *Liberty Dressing Company*, Gloversville, N. Y., *Liebel-Flarsheim Company*, Cincinnati, Ohio, *Machlett Laboratories*, Springdale, Conn., *National Synthetics*, New York, N. Y., *H. B. Odmann, Inc.*, Leonia, N. J., *Patterson Screen Company*, Towanda, Pa., *Philips Metalix Corporation*, New York, N. Y., *Picker X-Ray Corporation*, New York, N. Y., *Radium Chemical Company*, New York, N. Y., *Frank Scholz*, Boston, Mass., *Standard X-Ray Company*, Chicago, Ill., *Charles C Thomas*, Springfield, Ill., *Victoreen Instrument Company*, Cleveland, Ohio, *Westinghouse X-Ray Company*, Long Island City, N. Y.

NEW OFFICERS

At the recent meeting of the American Roentgen Ray Society held in Cincinnati, Ohio, September 23 to 26, 1941, the following officers were elected for the coming year: *President:* W. M. Doughty, Cincinnati, Ohio; *President-Elect:* Ralph S. Bromer, Bryn Mawr, Pa.; *1st Vice-President:* F. W. O'Brien, Boston, Mass.; *2nd Vice-President:* F. J. Hodges, Ann Arbor, Mich.; *Secretary:* H. Dabney Kerr, Iowa City, Iowa; *Treasurer:* J. Bennett Edwards, Leonia, N. J.; *Historian:* Ramsay Spillman, New York, N. Y.; *Member of the*

Executive Council: C. H. Heacock, Memphis, Tenn.

SCHERING AWARD

The Association of Medical Students is sponsoring a scholarship competition among medical students for the best dissertations on the history of endocrine research. They have been fortunate in obtaining as judges ten of the most important men in the hormone field. The augmented interest in endocrinological subjects which the Schering Award is bound to invoke may well help to advance the entire science of endocrinology.

MIDSUMMER RADIOLOGICAL CONFERENCE

The Seventh Midsummer Radiological Conference was held in Denver, Colorado, July 31, August 1 and 2, 1941, with headquarters at the Shirley Savoy Hotel. The meeting was sponsored by the Denver Radiological Club under the presidency of Dr. Elizabeth H. Newcomer. More than two hundred and fifty radiologists and other doctors interested in radiology registered from Colorado and the neighboring states.

Guests speakers were: Ross Golden, M.D., New York, New York; Leon J. Menville, M.D., New Orleans, Louisiana; David S. Beilin, M.D., Chicago, Illinois; U. V. Portmann, M.D., Cleveland, Ohio; John T. Murphy, M.D., Toledo, Ohio; John D. Camp, M.D., Rochester, Minnesota; Wendell G. Scott, M.D., St. Louis, Missouri; and Atha Thomas, M.D., of Denver, Colorado.

Scientific exhibits were provided by guests and local physicians. The program consisted of symposia on both diagnostic and treatment problems. Gratifying educational publicity was obtained through the local newspapers.

The Rocky Mountain Radiological Society was organized at a meeting on August 1, 1941. L. G. Crosby, M.D., Denver, Colorado, was elected President and A. M. Popma, M.D., Boise, Idaho, Secretary-Treasurer. The executive committee of the new organization is composed of the following: W. W. Wasson, M.D., Denver; F. B. Stephenson, M.D., Denver; L. G. Crosby, M.D., Denver; J. P. Kerby, M.D., Salt Lake City, Utah; M. Trueheart, M.D., Sterling, Kansas; and T. T. Harris, M.D., Omaha, Nebraska. This executive committee served as a constitution committee and a constitution submitted by Mac F. Cahal was tentatively accepted subject to further study and possible revision.

EASTERN CONFERENCE OF RADIOLOGISTS

The Eastern Conference of Radiologists will be held in New York City on Friday and Saturday, January 23 and 24, 1942. The Biltmore Hotel will be the headquarters for the meeting.

Vol. 46, No. 5

DEPARTMENT OF TECHNIQUE

Department Editor: Robert B. Taft, M.D., B.S., M.A., 105 Rutledge Ave. Charleston, S. C.

MULTIPLE EXPOSURE TECHNIQUE IN CONTRAST VISUALIZATION OF THE CARDIAC CHAMBERS AND GREAT VESSELS

By MARCY L. SUSSMAN, M.D., MORRIS F. STEINBERG, M.D., *and* ARTHUR GRISHMAN, M.D.*

From the Departments of Radiology and Electrocardiography, The Mount Sinai Hospital
NEW YORK, NEW YORK

VISUALIZATION of the cardiac chambers and major vascular trunks following intravenous injection of a concentrated organic halogen has been described completely by Robb and Steinberg,[1] the originators of the method. Ordinarily following the rapid injection of the solution into a median basilic vein, roentgenograms are made at the intervals at which opacification of the desired portions of the cardiovascular system is expected. We have found some difficulty in establishing proper timing. Robb and Steinberg recommend as guides the determination of the arm-to-lung (ether) and arm-to-carotid sinus (sodium cyanide) circulation times. For example, to visualize the right side of the heart and the pulmonary artery an exposure is made at a time after the beginning of the injection about 25 per cent less than the "ether" time. The aorta is ordinarily visualized at an interval about 25 per cent less than the "cyanide" time. The apparatus available in the average department of radiology does not permit making more than two or at most three exposures in rapid succession and rarely at shorter intervals than three seconds. It is evident that satisfactory visualization of desired structures is often a matter of chance. The examination may have to be repeated and the exposure times modified in accordance with the results obtained at the first injection. With an abnormal circulation, timing is proportionately more difficult.

Theoretically the best method for the examination should be a motion picture of the fluoroscopic screen made continuously during the circulation of the opaque material through the cardiovascular and pulmonary circuits. This was achieved by Robb and Steinberg[2] and Stewart, *et al.*[3] using a motion picture camera with a special high speed lens. We have successfully duplicated their procedure. Our technical factors are as follows: 85 kv. (single phase), 150 ma., two exposures of three seconds each, roentgen tube-screen distance, 27 inches, rotating target tube 2.0 mm. focal spot. The Patterson Fluoroazur intensifying screen particularly adapted for photography and an experimental Eastman "blue sensitive" film are used. The motion picture camera is equipped with a special f 0.85 lens.* Most cases can be examined with a camera speed of 16 frames to a second; heavier patients and oblique views may require 12 frames to the second.

The advantage of the motion picture method is that all phases of the circulation of the opaque material through the cardiovascular system are recorded. There is no timing problem provided the roentgen tube capacity is not exceeded. Furthermore, on several occasions, detail of a portion of the heart such as the pulmonary or aortic valve was recorded on one frame only. Hence consistent visualization of such a structure could be obtained only by the motion pic-

* Fellow of the Dazian Foundation for Medical Research.

* Kindly loaned to Dr. Arthur M. Master by the Eastman Kodak Company, Rochester, New York.

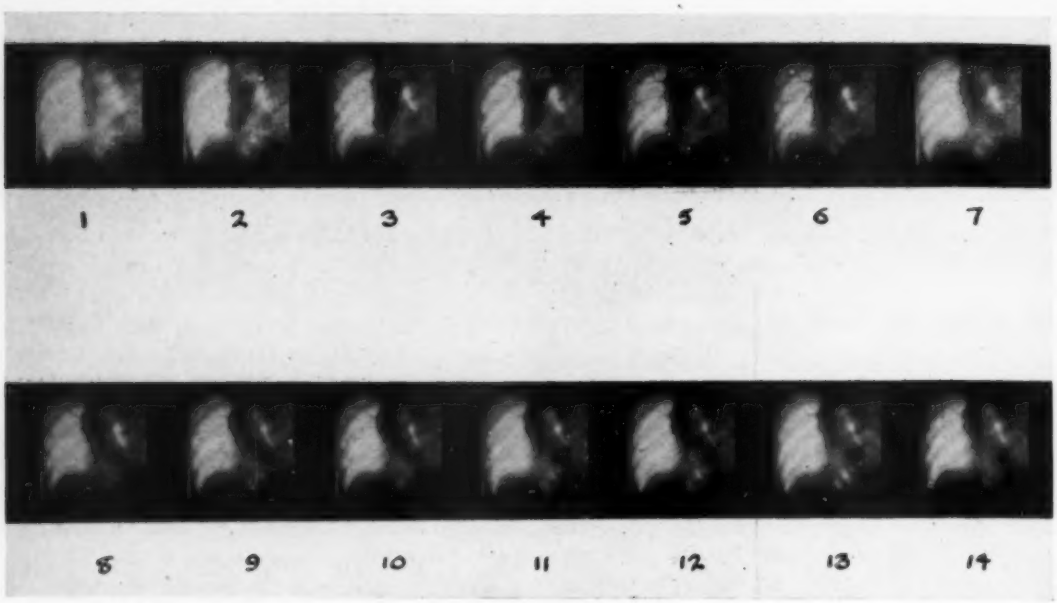

FIG. 1. Contact print of 35 mm. film. Fourteen exposures were made during ten seconds. Exposures 1 to 5 inclusive show the right side of the heart and the pulmonary arteries. Frames 8 to 14 show the left side of the heart, the aorta and the innominate arteries. In frame 4 the pulmonic valve can be identified by the incisure which it forms; in frame 9, the aortic valve.

FIG. 2*a*. An enlargement of frame 5, Figure 1.

FIG. 2*b*. An enlargement of frame 11, Figure 1.

ture method. The disadvantage is that a very rapid sensitive and, therefore, coarse grain emulsion film must be used, with consequent loss of detail. In addition, the apparatus is expensive and its use limited.

As a compromise between these two methods, the following procedure was developed and has been found satisfactory. A "still" camera is used with an arrangement for making exposures of the fluoroscopic screen in rapid succession. Our apparatus consists of either a Robot camera or a Leica camera with a Leica-motor which rotates a new section of film into position automatically after each exposure. This permits exposures to be made with ease every half second. Using an f 2.0 lens, in the average case, roentgen exposures of 0.3 second are used while the camera shutter is set at 0.5 second. Both mechanisms are released simultaneously. A Patterson B fluoroscopic screen and Agfa fluorapid film are used. The roentgenologic factors are 85 kv. (single phase), 150 ma., roentgen tube-screen distance, 27 inches. Using an f 1.5 lens, exposures of 0.2 second ordinarily suffice. A rotating target tube is essential for sharp detail. With this arrangement a minimum of ten exposures can be made during an eight second period of observation.

The advantages of this method are obvious. Instead of the two or three exposures which can be obtained when cassettes are used, at least ten and often sixteen can be made during an eight second period of observation. There is no need to depend upon the circulation time except where there is reason to suspect marked prolongation. Furthermore, since direct inspection of the fluoroscopic screen is possible while the camera is operated, exposures may be continued until part or all of the circuit is completed. The cost of the apparatus is relatively small. The cost of each examination, as far as the film is concerned, is negligible. In general, the film detail has been satisfactory. In addition, positioning of the patient can be done under direct vision. The main disadvantage is the possibility that certain small structures such as the cardiac valves may be missed by any method other than the continuous motion picture described above.

Occasionally the density of the structure to be visualized is slight, and direct roentgenography is highly desirable. In this case we have found the use of a conventional polygraph quite satisfactory. Using the apparatus designed for 14″ by 17″ roentgen films, four exposures can be made, each 7″ by 8½″. By positioning the patient fluoroscopically, most of the heart and aorta can be included. Exposures may be made as rapidly as the polygraph tray can be shifted. Ordinarily, therefore, exposures can be made with ease at intervals of one and one-half to two seconds or longer, as desired.

REFERENCES

1. Robb, G. P., and Steinberg Israel. A practical method of visualization of the chambers of the heart, the pulmonary circulation, and the great blood vessels in man. *J. Clin. Investigation*, 1938, *17*, 507.

2. Robb, G. P., and Steinberg, Israel. Visualization of the chambers of the heart, the pulmonary circulation and great blood vessels in man; summary of method and results. *J. Am. M. Ass.*, 1940, *114*, 474–480.

3. Stewart, W. H., Breimer, C. W., Steinberg, I., Robb, G. P., and Roche, U. J. Cineroentgenography of the chambers of the heart, the pulmonary circulation and the great blood vessels. Read before the Fortieth Annual Meeting, American Roentgen Ray Society, Chicago, Ill., Sept. 19–22, 1939.

INDEX TO ABSTRACTS

ROENTGEN DIAGNOSIS

Skeletal System

McCULLOUGH, J. A. L., and SUTHERLAND, C. G.: Epiphyseal dysplasia punctcularis... 749
CAMPBELL, A. M. G.: Carcinomatosis of bone 749

Blood and Lymph System

ZIFFREN, S. E.: Accidental perivascular injection of thorotrast..... 749

ROENTGEN AND RADIUM THERAPY

OVERGAARD, K., and OKKELS, H.: Action of dry heat on Wood's sarcoma..... 750
HANSSON, C. J.: Kaposi's sarcoma..... 750
REISNER, A.: Value of roentgen and radium treatment in diseases of the skin..... 751
BODE, H.-G.: Practical use of roentgen and radium rays in skin diseases..... 751
HALTER, K., and LUNDT, V.: Experience in the indirect roentgen irradiation of lichen ruber planus and progressive sclerodermia 752
LATCHMORE, A. J. C., LA TOUCHE, A. A. D., and SCHUCKSMITH, H. S.: Acute suppurative parotitis..... 752
ROBINSON, G. A.: Radium therapy in polypoid ethmoiditis..... 753
MAXFIELD, J. R., JR., and MARTIN, C. L.: Evaluation of roentgen therapy in sinus disease..... 753
GRILLI, A.: Radium treatment of advanced forms of carcinoma of the mucous membrane of the cheek..... 753
COUTARD, H.: Present conception of the treatment of cancer of the larynx..... 754
McCREADY, J. H.: Surgical treatment of cancer of the larynx..... 755
MARTIN, H. E.: Variations in radiation technic and biologic effects in the treatment of pharyngeal cancer..... 755
ELWARD, J. F., and DODEK, S. M.: Roentgen therapy in acute puerperal mastitis..... 756
OWEN, S. E., and WILLIAMS, A. E.: Irradiation and hereditary mammary cancer..... 756
GOIN, L. S., and HOFFMAN, E. F.: A new approach to the treatment of certain bladder carcinomas..... 757
CARSON, W. J.: Tumors of the penis..... 757
VOSS, F.: Methods used in Bering's roentgen treatment of progressive paralysis..... 757
OCHSNER, H. C., and MUMFORD, E. B.: Roentgen therapy for painful conditions of the bones and joints..... 758
MORRISON, M. C.: Distribution of radiation in pervaginal roentgen therapy..... 758
PECK, W. S., McGREER, J. T., KRETZSCHMAR, N. R., and BROWN, W. E.: Castration of the female by irradiation..... 758
TEPERSON, H. I.: Treatment of carcinoma of the rectum by electrocoagulation and radiation, in selected cases..... 759
DEN HOED, D., HOUWEN, J., and KWIESER, M.: The "supervoltage" roentgen installation in the Antoni van Leeuwenhoekhuis at Amsterdam. II..... 760
DEN HOED, D., and STOEL, G.: The "supervoltage" roentgen installation in the Antoni van Leeuwenhoekhuis at Amsterdam. III..... 760
EWALD, O.: The high voltage apparatus of the Heidelberg Samariterhaus..... 760
STEEL, D.: Two years' experience with 400 kv. constant potential deep therapy..... 761
LUCAS, C. DEF.: The therapeutic and economic indications for teleradium and the supervoltage x-ray machine..... 761
SCHINDLER, R.: Principles of a new therapy with high speed electrons..... 761
LEVITT, W. M.: Treatment of lymphadenoma and certain malignant growths with x-ray baths..... 762
BENDER, M., and KOHLER, A.: Measurements in pendulum irradiation..... 762
HANDLEY, W. S.: Improved outlook in x-ray carcinoma..... 763

MISCELLANEOUS

RENDICH, R. A., and HARRINGTON, L. A.: Why the film size?..... 763
WHEELER, D., and SPENCER, E. W.: Simplified planigraphy..... 763
KAUFMAN, J., and KOSTER, H.: Serial planeography (serioscopy) and serial planigraphy 763
ESSENBERG, J. M., and KARRASCH, R. J.: An experimental study of the effects of roentgen rays on the gonads of the sexually mature domestic fowl..... 763
BRANSON, H., and KERSTEN, H.: Differential action of x-rays on the anterior and posterior regions of *Tubifex tubifex*..... 764
RICHARDS, O. W.: Yeast growth..... 764

ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

SKELETAL SYSTEM

McCullough, J. A. L., and Sutherland, Charles G. Epiphyseal dysplasia punctic-ularis (stippled epiphyses). *Radiology*, Feb., 1940, *34*, 131–135.

A case is reported in a white boy, aged nine, whose height, 45 inches, was that of the average boy six and a half years of age. He weighed 44.75 pounds. He had never had any illnesses of any importance. Roentgen examination showed bone development normal, except for the shortness of the bones. The humeri and femora showed fusiform enlargement of the lower ends but no bowing. The capital epiphyses of these bones and the epiphyses of the greater trochanters showed granular stippling with some irregularity and trumpeting along the metaphyseal borders. The picture was not at all that of rickets and the child did not have the clinical symptoms of rickets. The epiphyses of the elbow joints and wrists showed a mild degree of stippling. The epiphyses of the ankles and knee joints showed irregularity along the metaphyseal borders but no stippling. The epiphyses of the metacarpals, metatarsals and phalanges were normal. There was a marked epiphysitis of the whole spinal column but no stippling.

There was no delay in the development of the centers of ossification but only defective growth in length and the child did not have any signs of congenital hypothyroidism.

This disease apparently is a chondrodystrophy, but not necessarily of the achondroplastic type. It is probably caused by endocrine dysfunction, but not necessarily, as this case shows, by hypothyroidism.—*Audrey G. Morgan.*

Campell, A. M. G. Carcinomatosis of bone. *Lancet*, April 27, 1940, *1*, 777–780.

The symptoms of "rheumatism" are not infrequently produced by secondary carcinomatous deposits from a primary growth which has not been realized.

Spread of tumor cells to bone appears to be by way of the vascular system rather than by way of the lymphatics. Bones containing red marrow are most susceptible to growth of the transplanted cells. For this reason, the ribs, sternum, vertebrae and the proximal ends of the long bones are most likely to become involved. Trauma may be a factor conducive to growth. Secondary carcinomata in bones are not rare, particularly when the primary lesion is located in the breast, prostate, thyroid, lung, kidney, stomach, tongue, esophagus or suprarenal.

The essential clinical features include: (1) a prolonged period of pains—considered to be rheumatism; (2) loss of weight; (3) depletion of red blood cells; (4) abnormalities in diameter of the red cells, and (5) roentgenographic evidence of bone destruction.

The pains were usually gnawing, deep seated, intense and unrelated to movement. In some instances there was tenderness to digital pressure applied over the involved bones. Local applications such as heat and physiotherapy tended to aggravate rather than alleviate the pains and the ordinary analgesics were of no benefit. Osteo-arthritis should be ruled out (as it can, when there is freedom of joint movement) while fibrositis should not be diagnosed unless there are painful nodules.

The blood picture may be normal though hypochromic anemia was not uncommonly noted. These changes were believed to be due to toxic depression of the bone marrow. There may be immature red and white cells, a variable color index and a low platelet count (also seen in multiple myeloma, myelosclerosis, marble bones and erythroblastic anemia).

Roentgen findings are most important but they may be late. Lytic lesions may be interpreted as hyperparathyroidism—but the pains, n the case of metastases with normal blood calcium should serve to distinguish these two possibilities. There may be general signs such as wasting, loss of appetite and pyrexia. Pathological fractures may occur as the first evidence. —*A. A. de Lorimier.*

BLOOD AND LYMPH SYSTEM

Ziffren, Sidney E. Accidental perivascular injection of thorotrast. *Radiology*, Feb., 1940, *34*, 171–175.

Two cases are described, in the first of which a mass was produced in the forearm just below

the elbow by the accidental perivascular injection of thorotrast. In the second case there was diffuse scarring in the groin from spread of the thorotrast through the tissues.

The possible dangers of the accumulation of thorotrast in the tissues have been described. Very small amounts of radium may cause death if properly distributed through the body. Fibromas and sarcomas have been produced by the subcutaneous injection of small amounts of thorotrast into experimental animals.

In these two cases there was no evidence of radioactivity in the affected areas when tested with the Geiger-Müller counter. But thorotrast gives off large amounts of alpha rays which are filtered out by the skin and are not demonstrable with this counter. These are the rays which have produced such bad effects in occupational radium poisoning.—*Audrey G. Morgan.*

ROENTGEN AND RADIUM THERAPY

Overgaard, Kristian, and Okkels, Harald, The action of dry heat on Wood's sarcoma. *Acta radiol.*, 1940, *21*, 577–582.

Attempts to prove that heat has a destructive action on tumor tissue have generally failed due to the fact that the dosage of heat could not be determined accurately. The authors report experiments in which the temperature was measured throughout the treatment by inserting a thermo-needle. About 3,000 white mice were used for the experiments. The heat was applied locally to the tumors. Ordinary diathermy, short wave and ultra-short wave diathermy were used. In a considerable number of cases permanent local cure was brought about. The temperature used varied in the different groups of animals from 42 to 46°C. and the time of application from five to sixty minutes. The experiments show that heat has a selective action on tumor tissue, destroying it without injuring normal tissue; the effect depends on the temperature and the time of exposure but not on the wave length used.

In another series of experiments combined heat and roentgen treatment was used. A curve was plotted showing the proportion of cures obtained with roentgen doses of between 400 and 2,000 r. There was a considerable increase in the percentage of cures when slight heat treatment was given before or after the roentgen treatment. The effect did not depend on whether the heat was applied before or after the roentgen treatment, so it could not have been a question of activating the rays. Cures were brought about with dosages of heat and roentgen rays neither one of which would have been effective alone. The doses used were so small that they could be used without danger on human beings.

Histological examinations showed that this combined treatment has a selective destructive action on tumor tissue and that heat acts chiefly on the protoplasmic elements of the tumor cells, which is a different action from that of the roentgen rays.—*Audrey G. Morgan.*

Hansson, C. J. Kaposi's sarcoma. *Acta radiol.*, 1940, *21*, 457–470.

In 1872 Kaposi first described this disease. Nodules from the size of a peppercorn to that of a pea or hazelnut, brownish or bluish red in color, appear on the skin without any apparent cause. They are smooth and elastic and often resemble blood blisters. They may occur singly or in groups. They generally develop first in the sole or dorsum of the foot and soon spread to the hands. Later they may develop in smaller numbers on the legs, arms, face and trunk. They may ulcerate and they show a marked tendency to hemorrhage. The disease generally causes death in two or three years; it occurs predominantly in males over forty years of age. The histological structure consists of foci of fusiform spindle cells and a rich new-growth of capillaries between which there is pigmentation. Kaposi first called the disease idiopathic, multiple, pigmented sarcoma but he later changed it to idiopathic, multiple, hemorrhagic sarcoma. No treatment except arsenic was known for the disease until after the introduction of radium therapy.

The disease is quite rare and occurs chiefly in southeastern Europe, particularly Italy, Poland and Russia. The author has seen 23 cases at the Radiumhemmet in Stockholm, 18 of them in men and 5 in women. All of the patients except three belonged to the laboring classes but this may have been because the patients at the Radiumhemmet are chiefly of that class. Kaposi never mentioned cases with a single tumor, probably because most of his patients came late for treatment. Seven of the author's patients had solitary tumors on the first examination; in 5 of these further tumors developed during the period of observation but 2 never had but one tumor. However, these were under observation for only a short time.

There has been considerable discussion as to whether these are true sarcomas or only some form of chronic inflammatory granulation tissue. Histological examination in the author's cases did not contribute anything to the solution of this question.

All of his patients were given irradiation, with no other form of treatment. Twelve were treated with roentgen rays, the total doses varying from 1,000 to 4,000 r on the surface. Treatments were given daily, 300 to 500 r each time. In all the cases the focus-skin distance was 23–50 cm. In 5 of the cases the filter was 1 mm. aluminum, 100 kv. In the other cases 4 mm. aluminum or 0.5 mm. copper and 1 mm. aluminum filter, 150–180 kv., 4 to 6 ma. In some of the more resistant cases a second similar series of treatments was given two to three months later. Five patients were treated by implantation or surface application of radium. The filtration was equivalent to 1 mm. lead. The dose in implantation varied from 10 to 40 mg. radium element for two and a half to four hours. For the surface application the dose was 150 mg. radium element applied for three hours at a distance of 12 mm.; the filtration was equivalent to 3 mm. lead. The remaining 6 patients were treated with both radium and roentgen rays, one method of irradiation being applied to some of the tumors and the other to others.

The tumors disappeared under both roentgen and radium treatment. The author thinks that, contrary to usual opinion, the prognosis is good. Seven of his patients have died but in none of the cases was there any evidence to prove that death was caused by Kaposi's sarcoma.—*Audrey G. Morgan.*

Reisner, A. Die Bedeutung der Röntgen- und Radiumbehandlung für die Krankheiten der Haut. (The value of roentgen and radium treatment in diseases of the skin.) *Strahlentherapie*, 1940, *67*, 584–602.

The author discusses the biological action of rays on the cell. The rays act on the atom by producing movements of the electrons. The transformation of a physical process into a photochemical effect is probably the first of a series of changes which result in what is seen as the action of the rays. In human tissues it is chiefly the albumin molecule that is affected. Roentgen irradiation probably acts primarily on the cell nucleus.

The action takes place at the site where the irradiation is absorbed. The length of the rays, that is the quality of the radiation, plays only a subordinate part.

The method of measurement based on ionization in air is the most nearly ideal one. Dosage based on Sabouraud tablets should be given up as it is too inaccurate. Differences in biological action between hard and soft rays are based on differences in absorption. There is no longer any justification for the so-called moderate deep therapy and it should no longer be used.

In the treatment of skin diseases an effort should be made to use a rational treatment, that is to use soft rays, as in this way the least damage is done to normal tissues.

The chief field for the use of radium in skin diseases is in angiomata and keloids and sometimes plastic induration of the penis. The more favorable effect in these conditions as compared with that of roentgen rays does not lie in a special sensitiveness of the cells but in the time factor. Slow irradiation is the reason for the better cosmetic results. Dosage can be carried out easily and accurately at present by the use of the photographic method or the *Drosophila* method and radium and roentgen dosage can be compared in roentgen units. At present such good results can be obtained in skin cancers with close roentgen irradiation that radium can be dispensed with entirely.

The importance of the time distribution of the dosage—protraction and fractionating—is discussed briefly. The comparative action of roentgen and radium radiation is a problem of quantity. If the doses and intensities of the two kinds of radiation can be made the same the effects are the same.—*Audrey G. Morgan.*

Bode, H.-G. Über die praktische Anwendung der Röntgen und Radiumstrahlen bei Hautkrankheiten. (The practical use of roentgen and radium rays in skin diseases.) *Strahlentherapie*, 1940, *67*, 603–624.

There has been a tendency in the past decade to limit the use of radiotherapy in skin diseases. This is doubtless due in part to the fact that many cases of injury by the rays have been seen and that they have frequently been seen in cases in which other methods of treatment would have served the purpose as well. The dermatologist is in a particularly difficult position with regard to the use of irradiation because he has to treat a skin that is already damaged and therefore much more sensitive than the normal skin through which the rays

pass in the treatment of deep diseases. Moreover skin diseases are often very chronic and the repeated treatments necessitated by this fact may lead to late injury.

The author advises great care in the use of roentgen treatment in eczema and thinks it should never be used in seborrheic eczema or in eczema in children.

In all roentgen treatment of skin diseases the principle of doing as little injury as possible to the skin must be observed. Recently there has been a tendency to use soft rays with a half-value layer of not more than 0.5 mm. aluminum and sometimes as low as 0.2 mm. In psoriasis as well as eczema soft rays and low dosage should be used and only in cases in which irradiation is strictly indicated.

In using roentgen treatment for epilation in children not more than four fields should be used and the dose of about 350 r given in four irradiations on two different days. The half-value layer should not be more than 1 mm. Al. The intensity should be 20 to 50 r/min.

Roentgen irradiation is of value in acute inflammations. The more acute the inflammation the lower the dose. No definite dose can be prescribed. The physician must decide in each case, Among chronic infections roentgen irradiation has given good results in inguinal lymphogranuloma. Irradiation has proved valuable in the treatment of acne vulgaris and the skin symptoms of leukemia and mycosis. It cannot be considered the treatment of choice in lupus. Indirect irradiation of the sympathetic has proved valuable in lichen ruber planus and to a lesser degree in progressive sclerodermia. Irradiation of the whole body has proved valuable in leukemia. Chaoul's method of close irradiation is the method of choice in cancer of the skin and lips; it has given a very high percentage of cures.

Radium has proved very effective in cavernous angiomas. Further indications for the use of radium are paraungual and subungual and plantar warts and leukemic skin infiltrations. Either Chaoul's close roentgen irradiation or radium should be used in epitheliomata of the skin.

The uses of thorium and grenz rays are discussed briefly.—*Audrey G. Morgan.*

HALTER, K., and LUNDT, V. Erfahrungen mit der indirekten Röntgenbestrahlung des Lichen ruber planus und der progressiven Sklerodermie. (Experience in the indirect roentgen irradiation of lichen ruber planus and progressive sclerodermia.) *Strahlentherapie*, 1940, *67*, 625–638.

Direct roentgen irradiation means the irradiation of the disease focus, while indirect irradiation means the irradiation of some distant organ for the purpose of treating the focus. In the case of lichen ruber planus the vegetative nervous system is irradiated. This method was introduced by Zimmern and Cottenot in 1919.

The previous work with this method is reviewed and the authors discuss 47 cases of ichen ruber planus and 8 of sclerodermia which they have treated by it. If the skin changes are generalized they irradiate the whole spinal column. Size of fields 10×15 cm., filter 0.5 mm. copper and 1 mm. aluminum, focus-skin distance 40 cm., 180 kv., 6 ma., dose ¼ skin erythema dose. Repetition after two weeks and if necessary up to six times at intervals of four weeks. The average time required for treatment in the 47 cases was four months. The results were successful in 65.4 per cent of the cases.

Cases that had developed recently reacted better than old ones. Cases that had been treated with arsenic and those that were provoked by salvarsan reacted particularly well. It is probable that preliminary arsenic treatment will improve the results of roentgen treatment. Mucous membrane foci and lichen ruber verrucosus and lichen ruber obtusus were not affected.

Indirect irradiation is superior to arsenic treatment alone in quickness of results, cosmetic results and harmlessness.

Eight cases of progressive sclerodermia were also treated. The results were successful in 4 cases and unsuccessful in four.—*Audrey G. Morgan.*

LATCHMORE, A. J. C., LATOUCHE, A. A. D., and SHUCKSMITH, H. S. Acute suppurative parotitis; treatment by deep x-ray therapy. *Lancet*, March 16, 1940, *1*, 497–499.

The authors speak enthusiastically as to the value of roentgen therapy for the treatment of acute suppurative parotitis. They emphasize the importance of instituting this treatment immediately upon evidence of swellings. The results obtained in 11 cases are cited. In 7 of these where treatment was instituted early, complete resolution took place in 5; resolution after incision of a local abscess in 1 case, while 1 died from causes other than parotitis. In 2 other cases, treated two days following the swelling of

the gland, 1 resolved completely while the other formed a local abscess. Two other cases were treated by roentgen therapy late (ten days or longer after swelling occurred) and both died.

The roentgen therapy consisted of 100 r daily or 200 r on alternate days (fields sufficient to cover area of swelling) until a total dosage of 500–600 r (to the skin) was attained. In most cases these treatments were given with 200 kv. (peak) using 1.0 mm. Cu filter and a focus-skin distance of 23 cm.

The authors believe that these infections are generally caused by the *Staphylococcus aureus* and that they progress because of dryness of the mouth, due to lack of salivation. Hence they occur particularly after abdominal operations. Dehydration should be offset by supplying 6 pints of fluid a day (continuous intravenous infusions—4 pints of 5 per cent glucose and 1 pint of normal saline). Careful hygiene of the mouth should be enforced and as a further prophylactic measure, chewing gum should be used to stimulate salivary secretions.

These infections are serious because of their tendency to develop necroses—definite abscesses—due to the resistance to the inflammatory changes by the fascial sheets. Finally, the fasciae do rupture and the infection may then dissect into the external ear, into the pharynx or down into the neck (with the likelihood of developing thromboses of the internal jugular vein and thereby a generalized pyemia).—*A. A. de Lorimier.*

Robinson, G. Allen. Radium therapy in polypoid ethmoiditis. *Radiology*, April, 1940, *34*, 449–450.

The author applies to each ethmoid area a 50 milligram radium capsule screened with 0.5 mm. platinum, giving 150 to 200 mg-hr. per treatment. An average of four treatments is given with an interval of ten days to two weeks between them. Vaseline packing is used to keep the capsules in position and is placed between the tube and septum so that the septal mucosa will not be burned. A double string is attached to a small ring in one end of the capsule and strapped to the patient's cheek and around the ear to keep the capsule from being dislodged and swallowed.

He does not give any information in regard to the number of cases treated but says that in his experience the mucoid and mucopurulent secretion has been lessened; headache has been relieved and in a few cases the sense of smell has returned; asthma has been controlled in the majority of cases when caused by the ethmoiditis; small polyps have disappeared and the intervals between recurrences have been lengthened. Complications such as necrosis of bone and perforated septum are very rare if care is used in the radium treatment.—*Audrey G. Morgan.*

Maxfield, J. R., Jr., and Martin, Charles L. Evaluation of roentgen therapy in sinus disease. *Radiology*, March, 1940, *34*, 300–310.

From 1850, when the modern conception of sinus disease developed, up to about 1915 surgery was the treatment of choice. But it was found gradually that sinus surgery only necessitated more sinus surgery and now there is a greater tendency to conservatism.

The authors report 57 cases treated by roentgen therapy. They had the best results in the chronic hyperplastic type of sinusitis. Their present technique is 200 kv., 25 ma., 50 cm. distance, 0.5 mm. copper and 1 mm. aluminum filter, treatment time ten minutes, which gives 400 r, measured in air, without backscatter through a single field, 15×15 cm. square over the region of the frontal maxillary and ethmoid sinuses. They have had only 18 per cent cures, which is much lower than the results reported by a number of writers, and even these they prefer to call relieved rather than cured. They have had very striking relief in some cases and these results justify the use of irradiation in cases not relieved by other methods, particularly as the treatment is very well tolerated. Needless to say it should be given only by a competent and skilled roentgenologist. They do not advocate the use of irradiation if there are soft tissue masses in the sinuses until after the masses have been removed surgically. They believe that irradiation should be used after all surgery on the sinuses in cooperation with the otolaryngologist and the physician who has referred the case.—*Audrey G. Morgan.*

Grilli, Adamo. Il trattamento curieterapica delle forme avanzate di carcinoma della mucosa della guancia. (The radium treatment of advanced forms of carcinoma of the mucous membrane of the cheek.) *Radiol. med.*, June, 1940, *27*, 440–452.

At the Radiological Institute of the University of Milan the early stages of carcinoma of the cheek are treated first by infixation of radium needles in the tumor, then by complete re-

moval of the regional glands and finally by transcutaneous radium therapy by means of modelled apparatus which covers the primary tumor and the regional glands. This same scheme cannot be used in very advanced cases because the cheek has often become rigid and fixed, and sometimes the jaw is locked because of invasion of the masseters so that it is difficult or impossible to introduce radium into the mouth.

The plan of treatment adopted at Milan for these advanced tumors is therefore first transcutaneous radium treatment of the primary tumor and the gland metastases by means of modelled apparatus. This reduces the size of the primary tumor and makes it possible to open the mouth and at the same time acts on the gland metastases which at this stage generally require immediate treatment. Tubes containing 5, 10 and 20 mg. radium are embedded in the apparatus at a distance of 5 cm. from the skin with a filter of 1 mm. platinum; the total amount of radium is 120–150 mg., arranged so as to get uniform irradiation of the whole area to be treated. The dose is 40 skin units in ten to fifteen days both on the primary tumor and on the glands. This is followed by intraoral irradiation of the primary tumor and surgical removal of the glands. Sometimes one and sometimes the other of these is given precedence. Generally intraoral treatment of the tumor is the second stage in the scheme followed by surgical removal of the glands. In some cases in which the action of the first stage has been rather slow the glands are removed before intraoral radium treatment.

Case histories of 17 cases treated in this way are given. In 7 of them all three stages of the treatment were given, in 5 only the first two stages and in 5 only the first stage. Tables are given showing details of results and the length of survival. Two of the patients are still alive after six years, though all these cases were at the extreme limit of operability.—*Audrey G. Morgan.*

Coutard, Henri. Present conception of the treatment of cancer of the larynx. *Radiology*, Feb., 1940, *34*, 136–145.

Report is made of the treatment of cancer of the larynx at the Curie Institute from 1921 to 1932. A total of 142 patients with inoperable cancer or recurrence was treated. Of these 39, or 27 per cent, have survived five years without symptoms; 19 out of 87 patients treated between 1921 and 1927, or 22 per cent, have survived ten years without symptoms and 6 out of 31 patients, or 19 per cent, treated between 1921 and 1923 have survived fifteen years free of symptoms. There are considerable differences in the results for different years and the author attributes this to the fact that in the more favorable years a greater number of radiosensitive cancers appeared for treatment. The total number of of five year survivals in cancers with early radiosensitiveness has been 75 per cent and that in cases with only late radiosensitiveness has been only 6 to 8 per cent. Cases of early radiosensitiveness are ones with undifferentiated or only slightly differentiated cells. Those with differentiated cells are much harder to cure. Often in the cases of five year survival a recurrence occurs in the sixth year. This seems to have happened most frequently in cases in which the daily doses were small, particularly if these small daily doses followed a period of larger doses.

Since the results in 1932 were little better than those in 1921 the author concluded that old methods of treatment had yielded all they could and it was time to look for better ones.

A careful study has shown that there are periods of maximal radiosensitiveness. The duration of treatment should be in inverse proportion to the degree of infiltration and immobilization of the tumor.

The use of high voltage radiation has brought about some improvement in the treatment of these cancers by making it possible to simplify methods of treatment. This has been accomplished by using a single field with a regular and daily decrease of its size and a regular and daily increase in the dose. The best results have been obtained with intensities of from 2 to 3 r per minute in the tumor with a total duration of from twenty-five to thirty hours for 7,000 r on the skin. An intensity of more than 10 r per minute seems to be one of the causes of intolerance to irradiation.

High voltage treatment has not given such good results as were expected in deep cancers of the uterus, prostate, rectum, bladder and esophagus but the results in differentiated cancer of the larynx, pharynx and mouth have been better than those with the old methods.—*Audrey G. Morgan.*

McCready, J. Homer. Surgical treatment of cancer of the larynx. *Radiology*, Feb., 1940, *34*, 146–148.

There are two types of laryngeal cancer, extrinsic and intrinsic. The former affects the soft tissues of the larynx and hypopharynx, and as there is an abundant lymph supply metastasis is apt to occur early. The intrinsic type affects the glottis or subglottis or both. There is less soft tissue involvement and a less abundant circulation of lymph; metastasis therefore occurs later and this type is much more favorable for operation. As a general rule, intrinsic cancers should be operated on and extrinsic ones treated by irradiation.

In any patient with prolonged hoarseness, pain in the larynx, expectoration of blood-tinged mucus or a feeling of foreign body in the larynx, roentgen examination should be made for tumor. It should be remembered that cancer of the larynx is not unusual in young people. The lungs and mediastinum should also be examined for possible metastases.

The author believes that with a careful study of the natural history of these growths the disease can be arrested in the precancerous stage by combined treatment with surgery and irradiation and that true malignancy will be seen much less frequently than it is now.—*Audrey G. Morgan.*

Martin, Hayes E. Variations in radiation technic and biologic effects in the treatment of pharyngeal cancer. *Radiology*, Feb., 1940, *34*, 149–165.

Before the fractional dose of radiation came into use cure of pharyngeal cancer was rare. Nevertheless other methods should not be abandoned entirely. The technique of fractional irradiation cannot be standardized so that it can be used in just the same form in all cases. At the Memorial Hospital in New York the average treatment for a small pharyngeal lesion is about 350 r daily through circular fields 7 cm. in diameter, first on one side of the neck and then on the other for a total of 3,500 r to each side of the neck in twenty days; 200 kv., 8–30 ma., 0.5 mm. copper and 2.0 mm. aluminum filter, 50–60 cm. target-skin distance. The different factors may be modified to suit the individual case and usually additional treatment is given at the end of twenty days.

In some cases interstitial radon must be used as a supplementary treatment. This may prevent some of the bad effects of very heavy dosage of roentgen radiation. It may also overcome a radioresistant residue or a distant lymph node.

Other variations in the biological effects following variations in the different physical factors of radiation are discussed in detail and illustrations and diagrams given of the apparatus and method of application of the irradiation.

Following this article on pp. 161–165 a discussion is given of the symposium on cancer of the larynx. Dr. Lenz of New York gave tables showing the results of treatment at Montefiore Hospital for 1931 to 1935. He said that in the cases in which only one cord was involved the number of recorded cures after laryngofissure was greater than that after roentgen therapy. But radiotherapy failed completely when both cords were involved and especially when the arytenoid cartilage was invaded and the cord was fixed. These patients survived only if the cartilage was removed surgically and postoperative roentgen treatment given.

As to treatment he does not believe that the r afflux per minute is as important as was formerly believed but that the size of the daily dose is more important. Recently their daily dose has not exceeded 300 r and has generally been less.

Dr. Coutard said that the treatment of cancer of the larynx is undergoing evolution and that he believed that in the near future both operable and inoperable carcinomas of the larynx would be treated by irradiation.

Dr. Costolow said that with improvement in irradiation few operations are being done now. During the past three and a half years at the Los Angeles County Hospital out of some 30 cases of cancer of the larynx only 3 were treated surgically and in 1 case this was at the patient's request. He believes that in highly malignant growths external irradiation is the treatment of choice. Generally speaking low grade carcinoma confined to one cord may be cured by laryngofissure or other surgical methods.

Dr. Harris said that he and Dr. Klemperer had studied 60 cases of cancer of the larynx and found that 80 per cent of them were highly differentiated. Of these 40 were treated by roentgen therapy and the response showed that the results of this treatment do not depend on the histologic grade of the tumor. This is especially true in cancer of the true cord.

Dr. Chevalier Jackson said that in the type of

cases described by Dr. McCready laryngofissure would give such good results that it should be used until the results of irradiation are better than they are now. The low-grade tumor gives better results either by surgery or irradiation. Other factors such as the location and extent of the tumor are more important than the histologic type but that in borderline cases the histologic type is the deciding factor. Among 106 cases treated before 1930 by irradiation he has only found 44 that had been definitely arrested and not one of the patients survived more than a year or a year and a half. This does not justify using irradiation in any operable case. Since 1930, 90 cases have been treated in his clinic by irradiation, 79 of them more than two years ago. Of these 17, or 21 per cent, are well two years or longer, the longest seven years.

High-grade tumors respond quickly to irradiation but not necessarily better than low-grade ones. They do not stand as good a chance of being cured permanently as the radioresistant, highly differentiated low-grade tumor. If the tumor disappears slowly and even needs some interstitial irradiation it is more apt to give the best late results.—*Audrey G. Morgan.*

Elward, Joseph F., and Dodek, Samuel M. Roentgen therapy in acute puerperal mastitis. *Radiology*, Feb., 1940, *34*, 166–170.

The authors report 25 cases of puerperal mastitis treated by irradiation. Eleven (44 per cent) were given treatment within forty-eight hours of the beginning of symptoms, 3 (12 per cent) within ninety-six hours and 11 (44 per cent) more than ninety-six hours after symptoms began. Pain was the chief symptom in all cases and there was some degree of fever in all. Fourteen cases (56 per cent) had fissures of the nipple. Of the 11 cases treated within forty-eight hours of the beginning of symptoms only one (4 per cent of the total cases, 9 per cent of the forty-eight hour cases) required incision and drainage. Twelve cases (48 per cent) were treated with 140 kv., 0.2 mm. copper plus 1 mm. aluminum filter and 30 cm. target-skin distance. Thirteen cases (52 per cent) were treated with 200 kv., 0.5 mm. copper plus 1 mm. aluminum, 50 cm. target-skin distance. None of the cases treated within forty-eight hours with 140 kv. (4 cases) developed abscess. Of the remaining cases treated within the first forty-eight hours with 200 kv. (6 cases, 24 per cent), only 1 case required incision and drainage. The other 10 incised cases were treated ninety-six hours or more after the beginning of symptoms. The fields covered the inflamed area with a considerable zone of normal tissue around it.

The authors believe that the most frequent avenue of infection is the fissured nipple. When the first signs of such lesions develop they should be treated with 5 per cent silver nitrate solution. When the nipple has become definitely fissured nursing should be stopped and a firm binder applied. Pain, swelling, redness and induration of the breast or fever are indications for roentgen treatment which should be begun at once. If this plan is followed puerperal mastitis complicated by abscess will be greatly decreased.—*Audrey G. Morgan.*

Owen, S. E., and Williams, A. E. Irradiation and hereditary mammary cancer. *Radiology*, May, 1940, *34*, 541–544.

It seems to have been proved that mammary cancer in mice is caused by the action of ovarian hormones on mammary tissue that has been conditioned by heredity. This conditioned mammary tissue is extremely sensitive to the action of ovarian hormones.

The authors experimented in the irradiation of a strain of mice that had been bred until they showed a high incidence of cancer of the breast —78 per cent of multiparous females with a mean observance age of 10.7 months.

Small doses of radiation (100 r) in such a group resulted in decreased incidence of mammary tumors. The decrease in cancer incidence over a five months' observation period after the irradiation was roughly proportional to the dose of radiation. While some of this cancer suppression may have been due to depressing the ovarian hormones non-sterilizing doses were effective. However, doses three times as large as the sterilizing dose were most effective. In none of the cases did irradiation increase the incidence of cancer. Histological examinations of controls showed that the tissues were non-cancerous at the time of irradiation.

The authors bring up the question of whether they were treating cancer successfully before it could be recognized histologically. They suggest a more careful study of this field of "latent cancerism" and investigation of other types of spontaneous tumors, especially ones that are not definitely influenced by endocrine factors.—*Audrey G. Morgan.*

Goin, Lowell S., and Hoffman, Eugene F. New approach to the treatment of certain bladder carcinomas. *Radiology*, Feb., 1940, *34*, 205–213.

As the results with the previous methods of treating carcinoma of the bladder have been so poor, the author proposes marsupializing the bladder and treating the tumor with low voltage roentgen therapy. The steps in the midline cystotomy and suturing the bladder to the superficial layer of fascia and to the skin are illustrated. The apparatus used, a Philips Metalix contact therapy unit operating at 50 kv. constant potential and 2 ma. current, is described in detail. The anode-surface distance is 22 mm. and the r afflux 1,278 per minute. Evipal anesthesia is used because some patients cannot bear the feeling of traction that results from holding the tube in contact with the tumor. The dosage has been as high as 2,556 r per treatment and the total dosage as high as 30,672 r given over a period of twenty-seven days.

Three cases are described in which the results were excellent. The number of cases is too small and the time too short to permit of definite evaluation of the method but the author believes that in selected cases it offers more hope than fulguration or cystectomy.

In the discussion Dr. Murphy said he thought the method was hopeful. He had used it in only 2 cases, one of which was too far advanced for this form of treatment but the primary result was excellent in the other. His technique differs a little from Dr. Goin's. He has simply opened the bladder and given the whole treatment at one time (10,000 r in thirty-five minutes) and then closed the bladder without drainage.

Dr. Goin said that it is remarkable how little reaction follows the massive amounts of radiation he has used in these cases. He says that Dr. Murphy suggested using a longer distance but he does not think this advisable because this method should be used only for cases in which the tumor has not extended beyond the bladder wall and in such cases increased depth doses are not wanted.—*Audrey G. Morgan.*

Carson, W. J. Tumors of the penis. *J. Urol.*, Sept., 1940, *44*, 307–313.

Penile cancer constitutes between 2 and 3 per cent of all male cancers. Most of these cases can be prevented by circumcision in early life. Penile tumors can be classified into benign and malignant. Tumors of the anterior urethra are considered with penile tumors. Benign tumors are (1) cysts, (2) lipomata, (3) myomata, (4) fibromata, (5) vascular tumors including aneurysm, venous varices and cavernous hemangiomata, and (6) papilloma. Malignant tumors include (1) epithelioma, (2) sarcoma, (3) melanoma, (4) endothelioma, and (5) teratoma.

Tumors arising in the deep urethra are usually squamous or basal cell epithelioma. These usually begin as pimples, flat ulcers or black spots. Early growth is slow. The author summarizes 12 cases, 10 of which were epithelioma. The treatment is analogous to the treatment of carcinoma of the breast. According to the literature the best prognosis occurs from radical surgical removal of the tumor mass and the draining lymphatics. This is the treatment of choice. Palpable lymph nodes are no contraindication to radical surgery. Most cases are given postoperative deep roentgen therapy.—*R. M. Harvey.*

Voss, Friedrich. Spezielles und Methodisches zur Röntgenbehandlung der progressiven Paralyse nach Bering. (Methods used in Bering's roentgen treatment of progressive paralysis.) *Strahlentherapie*, 1940, *67*, 693–699.

Bering was the first to use roentgen rays in the treatment of progressive paralysis on the theory that, as in other inflammations, the superimposed inflammation caused by the rays would bring about a change in the tissues that would affect the course of the disease. Malaria and roentgen rays exercise a long-continued effect on the brain tissue, in contrast with the transitory action of pyrifer and diathermia.

At first this method was used only for patients in whom malaria treatment was contraindicated, such as old and feeble patients and those with circulatory disease, such as specific aortitis.

The macroscopic changes in the brain in progressive paralysis are chiefly in the frontal region but microscopic examination shows slight changes throughout the brain; therefore radiation was applied to the whole brain but most intensely to the frontal region. The degree of activity of the inflammation can be determined by examination of the spinal fluid. In progressive active cases with a high lymphocytosis in the spinal fluid, treatment must be more cautious than in old resting cases, and must be given in fractional doses. No uniform dose can be given but in each case it must be based on the

stage of the inflammation, the form of the skull, the clinical findings and the course of the disease.

In general the author used 185 kv., focus-skin distance 30 cm., filtration 0.5 mm. copper and a half-value layer of 1 mm. copper. Using a tube with an opening 10×15 cm. the minute yield was 41 r. After trying various techniques he finally adopted the following, with variations of course adapted to the case. On the first day the forehead is irradiated with 60–80 per cent skin erythema dose, on the third day the vertex and the left temple with 30 to 40 per cent, on the fifth day the occiput and right temple with 40 per cent each, on the seventh day a suboccipital or nape of the neck field with 40 per cent. In this way a surface dose of 250 to 270 per cent S.E.D. is given and severe headache and total epilation avoided. If necessary, after three to four months the same dose can be given again without doing any harm.

The author has begun experiments in which he is determining the focal dose in different parts of the brain in the trephined skull of the cadaver, using a Siemens' universal dosimeter. The results of these experiments will be reported later.—*Audrey G. Morgan.*

OCHSNER, HAROLD C., and MUMFORD, E. B. Roentgen therapy for painful conditions of the bones and joints. *Radiology*, April, 1940, *34*, 444–448.

The authors discuss the results of roentgen therapy in a group of 90 cases with painful conditions of bones and joints. They included cases resulting from trauma, including postfracture cases, many of them associated with osteoporosis, cases of atrophic and hypertrophic arthritis and a few of osteomyelitis.

The technique was 200 kv., 25 ma., filter 0.5 mm. copper and 1 mm. aluminum, target-skin distance 50 cm. and fields varying in size according to the part to be treated. Four applications of 100 r were given with an interval of two or three days between treatments. The total dose was small.

The best results were obtained in the posttraumatic cases, particularly the ones with postoperative pain. The results were poorest in the group with no specific injury but possible muscle strain. The results were good in the arthritic cases, though the interval between treatment and relief was generally longer in these than in the traumatic cases. Occasionally the arthritic symptoms were aggravated for a while after treatment. The number of cases of osteomyelitis was too small to permit of judgment as to the effect. But in cases with drainage there was prompt decrease of pain, drainage became much less profuse and the healing of the wound seemed to be accelerated. On the whole, they believe there was a greater percentage of improvement in this whole group than could have been brought about by any other method of treatment.—*Audrey G. Morgan.*

MORRISON, M. C. Distribution of radiation in pervaginal roentgen therapy. *Radiology*, April, 1940, *34*, 451–456.

With all the improvements in radiation therapy only about 25 per cent cures are still obtained in the larger cancer clinics when all stages of cancer of the cervix are grouped together. The greatest difficulty lies in overcoming cancer of the parametrium without injuring the overlying tissues. If the cancer is limited to the cervix the problem is not so difficult.

Irradiation can be given through the vagina without exposing the superficial tissues. A bakelite speculum is fitted over the cervix and connected at its outer end with the short master cone attached to the shock-proof tube-head. Charts are given showing the distribution of the radiation given in this way. The dosage given to the pelvis in this way is apparently as effective as radium given by the usual methods in Stages I and II of carcinoma. The roentgen method has the advantage of avoiding excessive radiation to the canal, the bladder and rectum. Apparently it is not as effective as the use of radium in the colpostat in the vagina in treating the parametrium. But even with the colpostat radium applicators the depth dosage is only a small percentage of the surface dosage and no really satisfactory way of treating the parametrium seems to have been developed. Apparently progress must be made by developing a method of exposing the parametrium to a restricted beam of radiation from a large amount of radium in the vault of the vagina or by pervaginal roentgen treatment directed into the fornices of the vagina with the distribution adequately controlled.—*Audrey G. Morgan.*

PECK, WILLIS S., MCGREER, JOHN T., KRETZSCHMAR, NORMAN R., and BROWN, WILLIS E. Castration of the female by irradiation. *Radiology*, Feb., 1940, *34*, 176–186.

The authors studied the records of 334 patients treated with roentgen rays or radium for

benign pelvic lesions. They give a table showing the calculated depth dose delivered to the ovaries through anterior and posterior pelvic fields 20×20 cm. in size. One group of 72 patients were given 625 to 749 roentgens to the ovaries and all of these were castrated. In another group of 36 patients given 500 to 624 r, 34 (94 per cent) were permanently castrated. Taking the whole group that were given 500 or more roentgens, 142 (96 per cent) were castrated. Most of these patients were forty years of age or older and a larger dose is required to castrate younger women. Apparently from the results in their cases 625 to 749 r delivered to the ovaries will assure permanent castration regardless of age. But 90 per cent of patients can be castrated with smaller doses, ranging from 375 to 499 r.

They found it impossible to determine a dose that could be depended on to cause temporary castration. They give techniques and dosage tables for giving uniform ovarian doses to patients with varying sizes of pelvis. Benign uterine hemorrhage, whether caused by abnormal stimulation of the ovaries or due to normal menstruation can be stopped satisfactorily by irradiation of the ovaries. Castration by irradiation apparently does not injure the general health. Signs of the menopause are no more severe or frequent than after surgical castration.

In the discussion following the paper Dr. Bowing said that it has been definitely established that irradiation is the treatment of choice in a selected group of cases for the control of vaginal hemorrhage which may or may not be associated with fibroma of the uterus or varying degrees of ovarian dysfunction. He described the radium technique in use at the Mayo Clinic. The dose necessary for temporary castration depends largely on the patient—when menstruation began, previous surgical operations or the presence of chronic pelvic inflammation. He agreed with Dr. John G. Clark that the severity of the symptoms of the menopause depends on the nervous constitution of the patient.

Dr. Newell said that it is not right to give temporary castration for no one knows what hereditary defects it might cause in the children.

Dr. Phillips said he was delighted to hear that such a small number of cancers had developed following castration by irradiation. He was also interested in the effect on the sex life of these individuals. He found that such changes were largely psychic.

Dr. Peck in closing said that failures to produce castration with radium were probably due to deviation of the upper radium capsule away from the midline of the uterus into one of the cornua. He believes that proper psychotherapy might prevent any great change in the sex life. They have discontinued subcastration doses because they find them unreliable and because they did not know what defects might appear in future generations.—*Audrey G. Morgan.*

Teperson, Hyman I. Treatment of carcinoma of the rectum by electrocoagulation and radiation, in selected cases. *Radiology*, May, 1940, *34*, 610–617.

A little more than 5 per cent of malignant lesions are in the colon and the majority of these are within reach of the examining finger. The average time from the first appearance of symptoms until the patient consults a physician is twelve months and by that time the disease is usually fairly well advanced. Only 30 to 70 per cent of the patients are operable. Operation should be used in operable cases. In advanced cases colostomy relieves obstruction but does not prolong the patient's life. In all cases too advanced for surgery or in which operation is contraindicated because of general weakness, old age or heart or kidney disease or diabetes the author recommends treatment by electrocoagulation, followed by radium and roentgen irradiation. The tumor mass is removed by electrocoagulation, the technique of which is described in detail. Radium is then applied directly to the tumor base, using platinum tube with walls 1 mm. thick giving a dose of from 100 to 125 mg-hr. per square centimeter of surface. A new rubber "garden-hose" applicator for the radium is described. It is bent to fit the curve of the rectum. About three weeks after the subsidence of the radium reaction roentgen treatment is given.

At first the author used 200 kv., 6 ma., 50 cm. distance, 0.5 mm. copper and 1 mm. aluminum filters given over two anterior and two posterior fields, 15×15 cm. in size, with a total of 1,600 r to each field. For the past year he has used 400 kv., 4 ma., 70 cm. distance, 3 mm. copper plus 1 mm. aluminum filter over four fields with a total of 2,600 r to each field. He has had better recovery after this supervoltage treatment.

He has used this method in 26 cases, 16 males and 10 females. The average age of the patients was sixty-five years. There was no operative

mortality. Of the male patients 2 died within the first year and 3 within the second year. All the females are still living one after more than three and a half years.—*Audrey G. Morgan.*

den Hoed, D., Houwen, J., and Kwieser, M. The "supervoltage" roentgen installation in the Antoni van Leeuwenhoekhuis at Amsterdam. II. Physical measurements. *Acta radiol.*, 1940, *21*, 583–590.

An article in *Acta radiol.*, No. 1, 1940, described the supervoltage apparatus recently installed in the Antoni van Leeuwenhoekhuis at Amsterdam. It was found that the half-value of rays generated at 825 kv. and filtered through 0.5 mm. tin, 2 mm. copper and 0.5 mm. aluminum is 5.9 mm. copper. A pressedwood phantom was used to determine the backscatter with different sizes of field and it was found to be much less than with 200 kv. and a filter of 0.5 mm. copper and 1 mm. aluminum.

A further discussion of isodose curves is given in this article. They were determined for different fields and compared with those obtained with 200 kv. The deep dose curves were flatter with supervoltage radiation than with 200 kv. The intensity was less in the superficial layers, but in the deeper layers the harder radiation was of better quality; at a depth of even 10 cm. there was a relative gain of 7 to 15 per cent. At a depth of 10 cm. the gain was greatest in the largest field. At a depth of more than 10 cm., however, the gain was greatest in the smaller fields. Stone and Aebersold express this phenomenon as follows: "The ratio between the depth doses of the two types of radiation at various levels increases as the depth increases and as the size of the field decreases." The authors' measurements, however, confirmed this statement only with regard to depths of more than 10 cm.

The beam can be kept quite sharp in a phantom because the side-scatter is slight. Illustrations of the method and tables of the results are given.—*Audrey G. Morgan.*

den Hoed, D., and Stoel, G. The "supervoltage" roentgen installation in the Antoni van Leeuwenhoekhuis at Amsterdam. III. The action of ultra-hard roentgen rays on Drosophila eggs. *Acta radiol.*, 1940, *21*, 591–596.

The first biological experiment made with the supervoltage apparatus mentioned in the title was to test its effect on *Drosophila* eggs. A large number of eggs were irradiated and many tests made in order to get a curve that showed the action of these supervoltage rays as compared with those of lower voltage. With this apparatus the rays are generated at 825 kv. with a filtration of 0.5 mm. Sn, 2 mm. Cu and 0.5 mm. Al, and a comparison is made with rays generated at 180 kv. with a filter of 0.5 mm. Cu and 1 mm. Al. The curves for the two voltages are given. The destructive action of the 825 kv. rays was only about 70 per cent as great as that of the 180 kv. rays.

So far no explanation of this fact has been found. It is quite possible that it may lie in errors of dosimetry. The problem of standardizing ultra-hard rays has not yet been solved satisfactorily.—*Audrey G. Morgan.*

Ewald, O. Das Hochvoltanlage des Heidelberger Samariterhauses; Messergebnisse und Ausblick auf die praktische Arbeit mit 400 kv. (The high voltage apparatus of the Heidelberg Samariterhaus; results of measurements and review of the practical work with 400 kilovolts.) *Strahlentherapie*, 1940, *67*, 553–583.

For a long time there was a great deal of discussion as to whether cells were affected by the quality of roentgen rays or only by the quantity. Holfelder in his "Foundations of Modern Roentgen Therapy" came to the conclusion that only quantity is important and that it is not important to increase tension above the ordinary 200 kv. Later work, however, seems to show that higher tensions produce better results. v. Schubert has concluded that the best biological effects are obtained with 900 kv.

The first apparatus for producing roentgen rays that approximated gamma radium rays in their action was constructed at the California Institute of Technology, using tensions up to 1,000 kv.

The author describes and illustrates the apparatus now in use at the Samariterhaus in Heidelberg which works with a tension of 400 kv. Protective measures have been devised which are sufficient to prevent any injury either to patient or personnel even at 400 kv. Only one-tenth of the permissible dose of 0.2 r is reached. The scatter around the tube axis is considerably higher than it has been with former methods. The marginal irradiation of the fields is not distorted by the lead diaphragms, as it was assumed it would be, but the fields have absolutely sharp outlines. The intensity, even with

large fields, decreases only a very little toward the margins.

A new method is described of measuring the deep dose by the use of small spherical condensing chambers with the condiometer. These measurements are more accurate than those with the Hammer dosimeter. The advantage of the high tension method is that larger deep doses can be given with less scatter and less injury to the skin. The percentage deep dose measured on the patients themselves is quite different from that determined physically on the water phantom.

The 400 kv. apparatus gives decidedly better results in the treatment of blood diseases than former methods. With an experience of only three and a half years it is hard to give a definite report on the results in malignant tumors.—*Audrey G. Morgan.*

Steel, David. Two years' experience with 400 kv. constant potential deep therapy. *Radiology*, Feb., 1940, *34*, 187–192.

The author describes the 400 kv. constant potential deep therapy machine that he has been using for the past two years at St. John's Hospital, Cleveland, Ohio. All patients treated with high voltage have been given small daily doses over a long period of time. The daily dose is seldom over 140 r to any one field. The majority of his cases have been in very advanced stages of the disease. He describes 4 cases in detail, carcinoma of the rectum, bladder, cervix and breast, as showing the excellent results obtained. He does not claim that all similar cases will react as well. It will take time to show the true value of 400 kv. therapy. Properly given the method is radical and must be considered so. And until its value is more firmly established conservatism must be the watchword. But from his two years' experience he feels justified in saying that treatment with higher voltage and heavier filtration resulting in shorter wave length when used by the protracted method is a great advance in radiotherapy.—*Audrey G. Morgan.*

Lucas, Charles DeForest. The therapeutic and economic indications for teleradium and the supervoltage x-ray machine. *Radiology*, Feb., 1940, *34*, 193–199.

Enormous amounts of money have been spent in recent years in installing supervoltage roentgen-ray machines and accumulating radium element packs. The author discusses the qualities of rays furnished by a 200 kv. machine, a 700 kv. machine and a radium element pack with reference to depth dosage, selective action on cells and the production of threshold erythema. It has not been proved that the short wave roentgen ray or the gamma radium ray has any selective action on tumor cells. A chart is given showing the depth dosage curves for the three qualities of rays and it is found that there is little difference in the depth dosage furnished by the three. Tables are also given showing the number of machines required for carrying out the cancer control problem and their comparative cost. The conclusion is drawn that the problem of cancer control is not particularly furthered by the use of supervoltage radiation or radium element packs and that the cost is increased enormously. Treatment with 200 kv. radiation is probably the best form of treatment and by far the most economical.—*Audrey G. Morgan.*

Schindler, Richard. Principles of a new therapy with high speed electrons. *Radiology*, Feb., 1940, *34*, 222–234.

The therapeutic possibilities of electromagnetic wave irradiations such as ultraviolet, roentgen rays and radium, have been thoroughly investigated. But little attention has been given to the corpuscular rays. These are now being studied in the form of high speed electrons. An apparatus for producing high speed electrons is described and illustrated.

High speed electrons offer certain advantages over roentgen rays in the treatment of deep-seated lesions. They act more intensely in the depths than at the surface, while with roentgen rays it is hard to give the necessary depth dose without injuring the overlying tissues. Much higher physical and biological intensities can be attained with high speed electrons than with roentgen rays in a given unit of time. High speed electrons have a definite range while roentgen rays have not. Therefore it is possible to localize the action of the electrons in a well-defined zone.

With high speed electrons tumors can be treated that are inaccessible to the action of roentgen rays, such as tumors of the rectum and throat. Radioresistant tumors can be treated. Doses can be given to the tumor larger than those given to the surrounding tissues. Electrons will not cause irradiation sickness because of their short range. Glocker, the well-known roentgen-ray scientist, said at the International

Congress at Zürich that he believed that treatment with high speed electrons would be the treatment of the future.—*Audrey G. Morgan.*

Levitt, Walter M. Treatment of lymphadenoma and certain malignant growths with x-ray baths. *Lancet*, Feb. 3, 1940, *1*, 212–215.

Observations are recorded relative to the results of treatment of 202 cases of reticulosis neoplasm (other than reticulosarcoma and the leukemias) treated mainly at St. Bartholomew's Hospital between the years 1929 and 1939. The regimen of treatment was the "regional x-ray bath," a modification of whole body irradiation as proposed by Holzknecht in 1905. The objection to general body irradiation is that a sufficient dosage, as far as the neoplasm is concerned, is excessive as far as the normal tissues are concerned. For this reason, the author has given his treatments as baths confined either to the chest, the abdomen or to the chest and abdomen—but protecting the extremities.

Repeated blood counts were obtained for indications as to dangerous limits (these counts being made at three day intervals in most cases). During the earlier years, the kilovoltage used was 180, with a filter of 0.5 mm. Cu. Later, 200 kv. with a Thoraeus filter was used. The focal-skin distance varied from 60 to 140 cm. Four oblique fields were used, the body being protected above and below the required levels by lead.

For the thorax, 35 r to one field constituted the first treatment. The fields were alternated and the dosage increased until 200 r was given (through the large field) as a dose. In the absence of contraindications, these treatments were continued until as much as 1,000 r had been applied to each field (over a period of one month).

Abdominal baths were given in a similar manner, covering the limits from the level of the ensiform to inclusion of the inguinal glands. The initial treatment consisted of 25 r and the peak daily dosage, 150 r, but the same total—1,000 r per field, was attained.

Trunk baths included the field from the mandible to below the inguinal glands (equal to a combination of the other two fields). Treatment was begun with a dosage of 20 r and a maximum daily dosage of 125 r was the rule. The total dosage was about 600 to 750 r to each field, though in about half of these cases, treatments had to be interrupted.

Some of the indications which served to interrupt treatments were: reduction of the leukocyte count to 1,200 or less; reduction of the mononuclears to 200 or less per cu. mm. (though recoveries did occur even though the leukocytes fell to 500 and the lymphocytes disappeared entirely from the blood stream); bleeding gums, petechiae, etc. Sore throats were regarded with suspicion.

In 2 cases death was attributed to the roentgen irradiation—terminal symptoms including an agranulocytic angina and ulcerative pharyngitis, purpura and subcutaneous hemorrhages.

In several cases, thoracic and abdominal baths were repeated after several months and the follow-up dosages were well tolerated. Sterilization inevitably resulted in the abdominal and trunk cases.

Symptoms were relieved in practically all cases. Those showing a Pel-Ebstein fever (associated with abdominal deposits) showed spectacular response. Of the lymphadenoma group (103), 2 lived for seven years; 61, for five years. Of the lymphosarcoma group, 2 of a possible 7 survived five years. Of 8 cases of cancer of the testis, 4 have survived for five years.

The author is now using this type of treatment on cases of Ewing's sarcoma.—*A. A. de Lorimier.*

Bender, M., and Kohler, A. Über Messungen bei der Pendelbestrahlung. (Measurements in pendulum irradiation.) *Strahlentherapie*, 1940, *67*, 669–692.

The authors discuss a previous article (*Strahlentherapie*, 1939, *65*, 468) in which they reported experience with a roentgen tube that swings over the patient like a pendulum during the exposure. In this article they report further on that work. They give graphs showing the deep dose as influenced by the size and shape of the field, the angle of the pendulum and therefore the time of its swing, the position of the center of the pendulum and the distance of the focus from the skin. They also discuss the scattered radiation which in this form of treatment may reach a given point on the body before the direct radiation does.

From the results shown in these graphs they find that it is not always necessary to work with the best physical conditions in order to get the best medical results. By varying the factors discussed above—size and shape of field, angle of

the pendulum, position of the center of the pendulum and the focus-skin distance—the most favorable conditions for the best biological action of the rays can be very closely approximated. Many irregularities in the distribution of dosage can be compensated in this way and very good results obtained.—*Audrey G. Morgan.*

Handley, W. Sampson. Improved outlook in x-ray carcinoma. *Lancet*, June 22, 1940, *1*, 1122.

Following the first manifestations of a roentgen-ray carcinoma, the latent period prior to evidence of extension is so prolonged that the author recommends removal of regional lymphatics, without delay, in order to "cut the main line of dissemination in an early stage." Previously, the author reported the handling of 2 such cases among radiologists. This report deals with 5 additional cases, including a manufacturer of roentgenologic equipment, a radiographer, a surgeon, a radiologist and a radium technician.—*A. A. de Lorimier.*

MISCELLANEOUS

Rendich, Richard A., and Harrington, Leo A. Why the film size? *Radiology*, May, 1940, *34*, 536–540.

Apparently the size of the films now being manufactured for purposes of roentgen examination are based on nothing more logical than the standard sizes that have been used for generations in ordinary photography. The authors give measurements of various parts of the body, the chest, colon, kidney, skull, pelvis, etc., which show that these sizes are not well adapted to the anatomical size of the parts. For instance colon films are too short, chest films too long and urologic films too wide. The present sizes are not at all well adapted to making roentgenograms of the skull, long bones, etc.

The suggestion is made that the technical committees of the national roentgen societies should adopt a film standardization program in order to secure films large enough to make a roentgenogram of the whole of any part to be examined and of the right dimensions to avoid wastage.—*Audrey G. Morgan.*

Wheeler, Digby, and Spencer, E. W. Simplified planigraphy. *Radiology*, April, 1940, *34*, 499–502.

Planigraphy is a method by which any desired plane of the patient's body can be shown on the film. It is also called stratigraphy and tomography. It is accomplished by moving the tube and film during the exposure in such a way that the images of all objects in the selected plane occupy the same position on the film while the images of all objects above or below this plane are blurred. Twining developed an attachment for the Potter-Bucky table that made this possible. The authors' apparatus is a modification of Twining's. It is illustrated, its method of use described and the mathematical principles involved are discussed. The authors believe their apparatus fulfills all the 6 requirements laid down by Grossmann for successful planigraphy.—*Audrey G. Morgan.*

Kaufman, Julius, and Koster, Harry. Serial planeography (serioscopy) and serial planigraphy. *Radiology*, May, 1940, *34*, 626–629.

Planigraphy is a method of obtaining a roentgen film of any given plane in the body or object to be examined. By the method of planeography introduced by the authors in August, 1936, all of the planes of the object could be demonstrated and the depth of the planes determined by reference to a specially constructed curve, the standard depth curve. The planes could be localized and measured and by correcting the displacement and enlargement of the planeogram the object itself could be reconstructed.

Cottenot in 1937 described a method which he called thoracic serioscopy which uses the same basic principles as those of the authors' planeography. He says that the depth between the planes may be measured but the authors do not believe these measurements have any real value.

The authors analyze the limitations of serial planeography and suggest methods for overcoming them. The limitations of serial planeography apply to serial planigraphy also.—*Audrey G. Morgan.*

Essenberg, J. M., and Karrasch, Ralph J. An experimental study of the effects of roentgen rays on the gonads of the sexually mature domestic fowl. *Radiology*, March, 1940, *34*, 358–365.

The authors have previously studied the effects of roentgen rays on the gonads of embryos and young chicks. In this article they study the effects on those of mature fowls. They irradiated 61 fowls and used 10 as controls. Of the irradiated fowls 35 were roosters and 26 hens. Twenty-two of the males were given a single dose of 1,276 to 2,816 r; 13 were given three cumulative

doses with a total dosage of 1,800 to 4,200 r. Twenty of the hens were given a single dose of 400 to 2,176 r and 6 of them given three cumulative doses with a total of 1,800 to 4,200 r. The roosters given a single dose were killed one week after irradiation; all the other fowls were killed three weeks after irradiation. The results were practically the same as those in the experiments reported previously.

Injury of the seminiferous epithelium began with a dose of 1,276 r and destruction was complete at 2,400 to 2,800 r. The primary spermatocytes were injured first, followed by the secondary spermatocytes, spermatids, spermatogonia and Sertoli cells. The injury of the seminiferous tubules was greatest at the levels where cell proliferation was most active.

Injury of the ovarian follicle began at 400 r, the follicles disintegrated at 800 r and were completely destroyed at 1,800 to 2,200 r. Injury to the germinal epithelium began at 400 r and destruction was complete at 1,200 r. Cyclical activity on the part of the germinal epithelium is proved by the fact that areas of total destruction and areas of cellular proliferation existed at the same time in the same irradiated ovary.

Both the ovaries and testes showed habituation to the action of cumulative doses of roentgen rays. Hyperplasia of fibrous connective tissue was seen in the walls of small arteries of the ovaries and testes, in the medullary stroma of the ovaries and in the tunica albuginea of the testes. The rays did not cause any demonstrable changes in the interstitial tissue of the gonads of either sex.

Brown melanin-like pigment granules were found in both ovaries and testes and it seems probable that they were produced by the action of the rays.

The gonads of birds seem to be more resistant to the action of roentgen rays than the gonads of mammals. There was a great deal of variation in the individual fowls.—*Audrey G. Morgan.*

Branson, Herman, and Kersten, H. The differential action of x-rays on the anterior and posterior regions of *Tubifex tubifex*. *Radiology*, Feb., 1940, *34*, 200–204.

Experiments are described in the irradiation of *Tubifex tubifex* with an intense collimated beam of soft roentgen rays. When these animals are separated with a knife anywhere back of the tenth somite, regeneration of the posterior part occurs but no regeneration occurs when they are separated by roentgen irradiation. When the anterior tip or the heart region is irradiated the chief change is the formation of tuberosities at the site of irradiation and disintegration progressing away from the site of irradiation. When the middle section is irradiated the chief change in the abnormal animals which survive is that they break apart; sometimes both parts survive, sometimes one dies, generally the posterior part.

The animals may be killed by irradiating the whole body. When the dose of roentgen rays was too small to kill all the animals the surviving ones showed either no change at all or the death of the posterior part only.

The posterior part of the animals is evidently the most sensitive to irradiation. This is probably in accordance with the law of Bergonié and Tribondeau that roentgen rays act most intensely on cells whose reproductive activity is greater, whose metabolism rate is higher and those whose morphology and function are less definitely fixed.—*Audrey G. Morgan.*

Richards, Oscar W. Yeast growth: a possible test growth for x-radiation. *Radiology*, March, 1940, *34*, 317–326.

The author describes experiments made to determine whether yeast is a suitable test object for the effect of irradiation with roentgen rays. He used a pure strain of *Saccharomyces cerevisiae* and irradiated with from 9,500 to 28,500 r at 70 kv. and with 200 to 38,000 r at 200 kv. under established conditions for the growth of yeast. The increase in the number of cells per unit volume of culture is retarded by the roentgen rays. Recovery takes place gradually and the irradiated cultures reach about the same equilibrium growth at the end of the growth cycles as that of the controls. A number of criteria of growth should be used to give reliable results, such as the increase in the number of cells in a unit volume of culture medium, the optical density, the percentage of buds and the percentage of cells stained with methylene blue.

It is believed that with a pure strain of yeast grown under the proper conditions yeast will be a useful test organism for the analysis of the effects of larger amounts of radiation and that the method described here will be of value in experimental biology and medicine.—*Audrey G. Morgan.*